INDEX

NMED's Concern
EPWU AE Exemption

NEW MEXICO
ENVIRONMENT DEPARTMENT

Ground Water Quality Bureau

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BILL RICHARDSON
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WASTE PERMITS DIVISION
TEXAS COMMISSION ON
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LLH

March 31, 2009

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Underground Injection Control Program
MC-130
Texas Commission on Environmental Quality
PO Box 13087
Austin, Texas 78711-3087

Build a table of Contents & Place in binder

RE: New Mexico Environment Department Comments on Aquifer Exemption Request for Class V Injection Wells (Authorization No. 5X2700062)

Dear Sirs:

The New Mexico Environment Department (NMED) has reviewed the Aquifer Exemption Request for Class V Injection Wells, Authorization No. 5X2700062, (request) submitted by Brad Cross of LBG-Guyton Associates on September 3, 2008 on behalf of El Paso Water Utilities. NMED has several comments and concerns regarding the proposal as discussed below:

UE DATE__________

RTS# 1264952-1

M B. Smith
EAM ☐ Admin ☐ 1 ☐ 2 ☑ UIC

1) NMED disagrees with the request's conclusion that "The aquifer is laterally continuous across the region with upper and lower confining units providing adequate containment". The proposed aquifer exemption area extends approximately 50 kilometers to the southeast crossing nearby geologic structural offsets (see Figures 7 through 9 of the request) and the more distant uplift(s) of the Hueco Mountains to the east and southeast. Figures 7 through 9 of the request show structural offsets that juxtapose the injection zone with a confining zone less than two kilometers from injection wells. Further, the amount of displacement of the Hueco Mountains is not given and could also create a discontinuity in the injection zone five to twenty kilometers from the injection wells. This potential discontinuity would not be accounted for by the modeling. Geologic cross-sections showing the relationship between geologic structure and the proposed aquifer exemption area were not provided. Based on a review of the information contained in the request, NMED concludes that the modeling assumptions that the injection zone is homogeneous and isotropic are not supported by the factual information presented in the request.

2) The modeling in the request uses the maximum measured hydraulic gradient, which is conservative for estimating velocity and down-gradient impacts; however, it is **not** conservative for estimating the distance and concentrations of up-gradient impacts into New Mexico.

3) NMED disagrees with the request's conclusion that "The remoteness and depth (2,200 to 2,890 feet) renders the aquifer an economically and /or technologically impractical source of drinking water". In New Mexico, saline ground water from deeper depths is currently being developed for use as a drinking water source for public water supply systems. In addition, the New Mexico Legislature recently passed legislation that has been signed by the Governor allowing the Office of the State Engineer to declare and regulate water quantity in aquifers such as the one described in the request.

4) The request's statement in the Conclusions Section that "Under current conditions, the chemical composition of the desalinization concentrate (injectate) has a TDS less than 6,000 mg/l. Thus, the concentrate has an overall higher quality that the proposed aquifer" is accurate. However, the injectate TDS concentration will increase significantly after the approval of the aquifer exemption because the blending of potable water with the desalinization concentrate will no longer be required by the Texas Commission on Environmental Quality.

For the reasons given above, NMED cannot support the aquifer exemption request based on the information provided.

If you have any questions regarding this matter, please contact me at 505-827-2919.

Sincerely,

William C. Olson, Chief
Ground Water Quality Bureau

WO:JH

cc: Jon Goldstein, Deputy Secretary, NMED
Marcy Leavitt, Director, Water and Waste Management Division, NMED
Tracy Hughes, General Counsel, NMED

TCEQ's critique of the first application

Peer review
of
Aquifer Exemption Request for Class Injection Wells
(Authorization No. 5X2700062)
by
David H. Murry, P.G., TCEQ
April, 2009

Conclusions and Recommendations

The prediction of the location and extent of the contaminant plume, which is the basis for the area requested for exemption, is not justified by the information presented in this application. There are two major deficiencies. First, the request ignores the structural aspects of the region, and the possible effects those aspects will have on the contaminant plume. Second, because of the structural aspects of the area were ignored, the conceptual model on which groundwater modeling is based is flawed.

my concern w application #2

I believe these deficiencies are such that the application should be returned; I do not recommend a notice of deficiency letter. If the applicant decides to pursue an aquifer exemption, the work done by Granillo (discussed below), which was funded by the applicant, should be seriously considered in constructing a geologic model on which to base groundwater flow and the dispersal of contaminants from injection activities.

Geologic Structure

Based on work done by Granillo[1], the existing Class V injection wells are in the McGregor Basin, which is a graben of about 2200 acres that lies within the McGregor Shelf Figure 1 and Figure 37 from Granillo). This shelf is a structural block that lies between the Hueco Bolson on the west and the Diablo Plateau on the east. Granillo's work indicates that geologic units within the McGregor Basin are structurally separated from the same units on the Diablo Plateau. This is true for the Silurian Fusselman Formation, which is the injection zone for the Class V injection wells being operated in the McGregor Basin. Granillo describes the McGregor Basin as a closed feature that geometrically resembles a bath tub, whose sides primarily consist of Paleozoic and Mesoproterozoic bedrock. Based on the geophysical results of the McGregor Basin and 30 year water injection simulation studies, Granillo's preliminary conclusion was that the McGregor Basin is a suitable natural reservoir for a deep injection well[2]. Information provided by Granillo indicates that fluids injected into sedimentary units within the McGregor Basin will stay within the basin.

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[1] Granillo, J. A., Jr., 2004, A Gravimetric Study of the Structure of the Northeast Portion of the Hueco Bolson, Texas, Employing GIS Technology, unpublished master's thesis, Univ. Texas-El Paso, 127 pages.
[2] *Op. cit.*, page 79

Fusselman appears separated &/discontinuous due to faulting on eastern flank

Although Granillo's work is referenced in the report, and copies of his gravity map and gravity profiles are provided, the report appears to completely ignore Granillo's structural synthesis of the area. With regards to the continuity of the Fusselman Formation, the report simply concludes that the formation is continuous from the injection site eastward to the Permian Basin[3]. Apparently, no consideration was given to the structural separation between the McGregor Basin and the Diablo Plateau.

Granillo's work clearly illustrates that the injection site is within a small graben[4], which is structurally isolated from the area to the east. Any conceptual model used to predict the movement of injected fluids must take this fact into consideration. However, as discussed below, the report concluded that any injected fluids would migrate over 30 miles to the southeast across the structural boundary between the McGregor Shelf and the Diablo Plateau.

Groundwater Modeling

Groundwater modeling was performed to predict the extent of the contaminant plume. The boundary of the plume was taken to be ¼ mile outwards from the points at which the concentration of the injectate will have been reduced to 1/1000th of its original concentration after 50 years of injection. The area of this plume, as predicted by modeling, extends from the injection wells about one-half mile northwestward into Otero County, New Mexico, and about 30 miles southeastward through the Hueco Mountains and onto the Diablo Plateau Figure 15 from the report). Total area of the requested exemption is 108,000 acres, with a vertical extent of 2480 feet (from the top of the Silurian Fusselman dolomite to the base of the Ordovician Bliss Sandstone).

<u>Potentiometric Surface</u>

As illustrated on the geologic map in Figure 5 of the report, Ordovician and Silurian rocks crop out about 15 miles southeast of the injection wells, along the southeastern boundary of the Diablo Plateau. According to information on the Van Horn-El Paso Sheet of the Geologic Atlas of Texas[5], these rocks represent the Ordovician Bliss Sandstone, the El Paso Formation, the Montoya Dolomite, and the Fusselman Dolomite. On page 17 of the report, these formations are identified as those of the proposed exempt aquifer. Therefore, rocks of the proposed exempt aquifer actually crop out southeast of the injection wells. Topographic information on this map indicates the base of the Bliss Sandstone crops out at an elevation of about 4100 feet.

Fusselman El Paso group outcrop

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[3] Page 7, Aquifer Exemption Request for Class V Wells (Authorization No, 5X2700062), August, 2008, prepared for El Paso Water Utilities by LGB-Guyton and Associates, Austin, Texas

[4] See Top of Fusselman Dolomite Map by Murry, attached, constructed from data provided in Granillo document.

[5] Geologic Atlas of Texas, Van Horn-El Paso Sheet, 1967, Bureau of Economic Geology, Univ. Texas-Austin.

Figure 11 of the report is a map of the assumed steady-state potentiometric surface for groundwater in the proposed exempted aquifer area. A comparison of this potentiometric surface to the geology illustrated in Figure 5 indicates that the assumed potentiometric surface for the groundwater in the proposed exempted aquifer area is at an elevation of 3250 to 3450 feet in the area where Ordovician and Silurian rocks crop out. In that the base of these rocks occurs at an elevation of about 4100 feet in this area, the assumed potentiometric surface associated with groundwater in these units is 650 to 850 feet below the base of these units. Clearly, at least in this area, the elevation of the assumed potentiometric surface associated with groundwater in the proposed exempt aquifer is incorrect. Therefore, the results of any groundwater modeling based on this assumed potentiometric surface are questionable.

Hydrologic Gradient

On page 21, LBG-Guyton stated that the hydraulic gradient between wells JDF-1 and JDF-3 is 0.0007 ft/ft, and that this gradient was used for groundwater modeling. Based on the well locations provided on Figure 7, this gradient represents a groundwater flow direction of S 45° W. However, the assumed hydraulic gradient used for groundwater modeling is S 40° E (Figure 11). It is unclear why a groundwater flow direction of S 45° W was assumed. The only apparent justification for assuming a southeast direction for groundwater flow is a statement on page 18 of the report that in general, groundwater in the Diablo Plateau region flows to the south and east, discharging in the Dell Valley and Salt Flat areas. However, no documentation was provided in the report to substantiate this statement.

Additionally, it is unclear as to why the magnitude of the hydrologic gradient between wells JDF-1 and JDF-3 (0.007 ft./ft) was used to characterize the hydrologic gradient over the area that was modeled (Figure 11 of the report). This gradient, which was measured between two wells that are about 3300 feet apart, was extrapolated to represent the hydrologic gradient over an area 28 miles by 66 miles, and then only after the direction of the gradient was rotated almost 85 degrees. No justification was given for this extrapolation or rotation.

Furthermore, the 28 mile by 66 mile area to which this gradient was assigned spans parts of the following structural provinces: Hueco Bolson, McGregor Wedge, Hueco Mountains, and the Diablo Plateau. Despite the structural differentiation of each of these entities from one another, the report apparently gave no consideration to the effect this differentiation may have on groundwater flow between these various structural provinces. Groundwater modeling simply was based on a uniform southeast-directed groundwater flow direction with a uniform gradient.

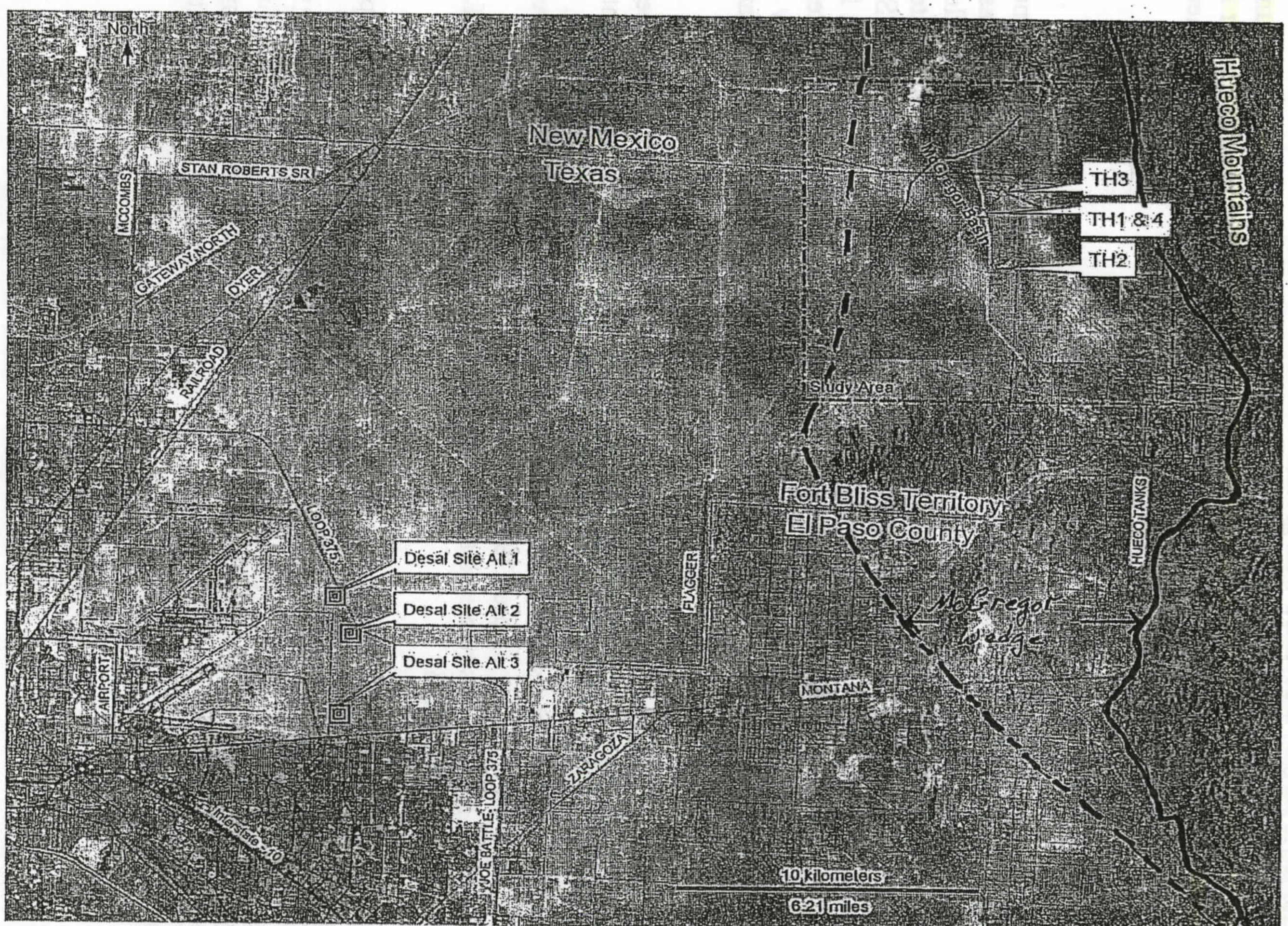


Figure 1. Location map showing the study area relative to the eastern portion of El Paso County. This illustration also provides the location of the 4 exploratory test well,s and three alternative sites being considered for the desalination plant to be built in 2005-06.

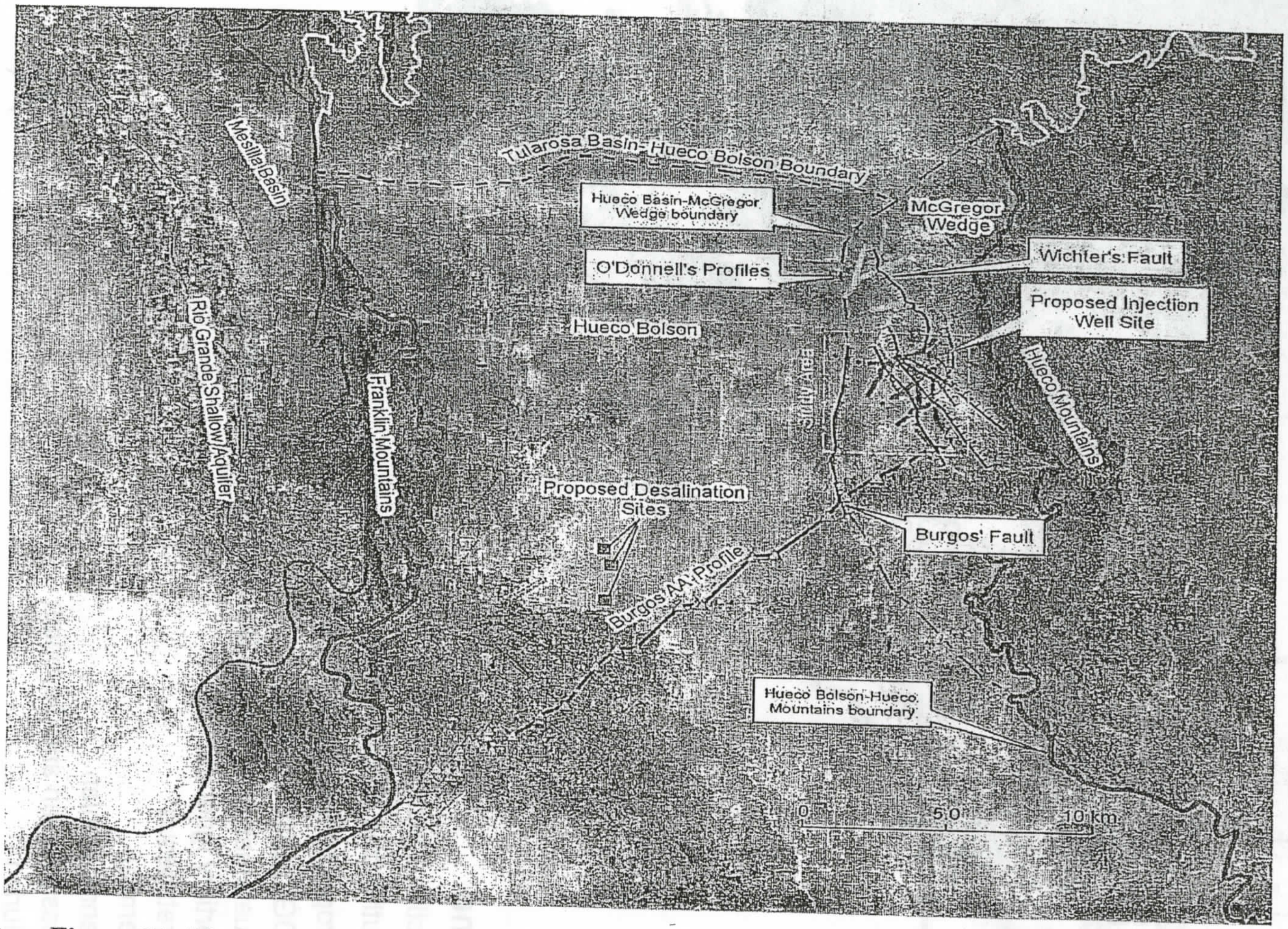
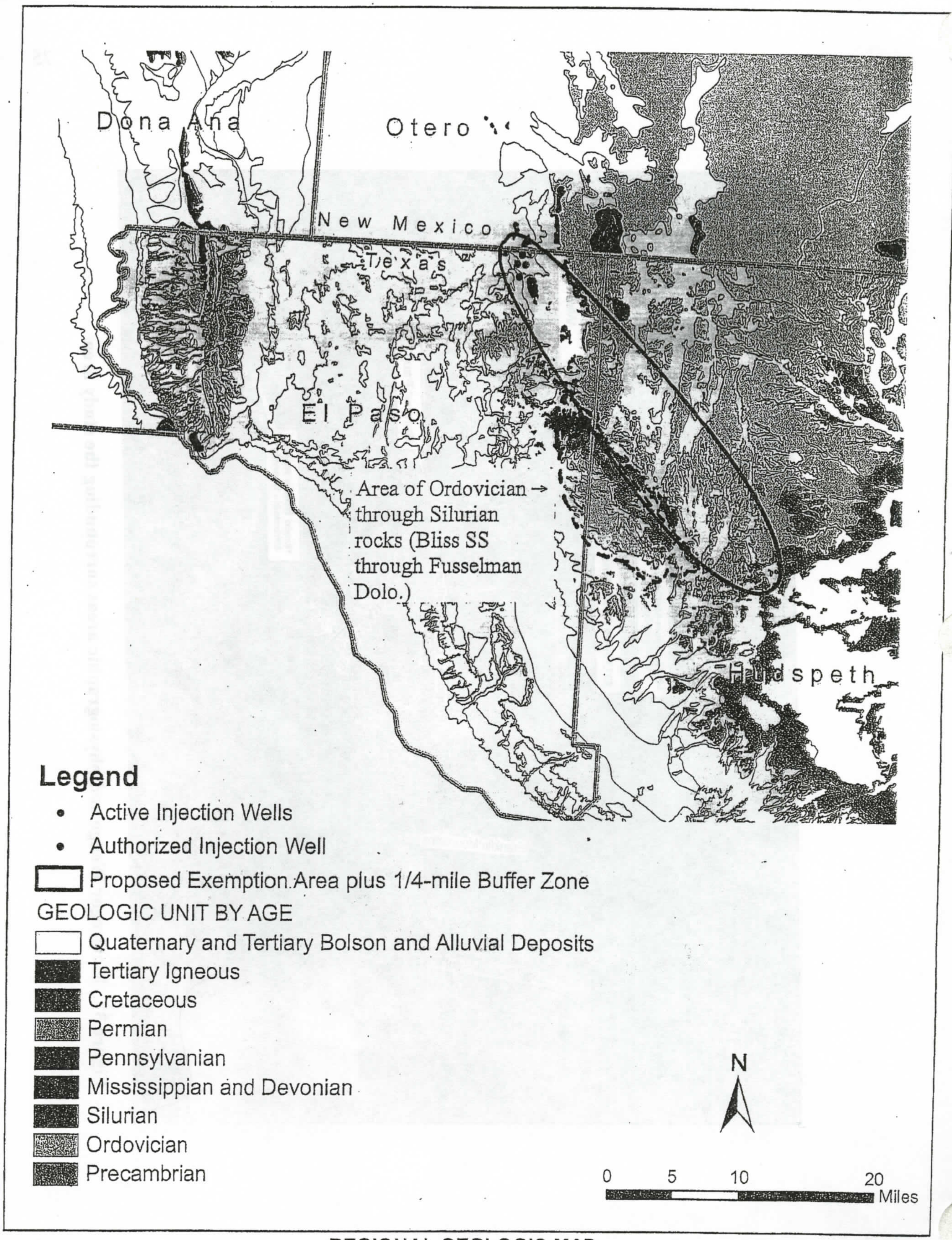


Figure 37. McGregor Wedge and physiographic areas surrounding the study area.



REGIONAL GEOLOGIC MAP

FIGURE 5

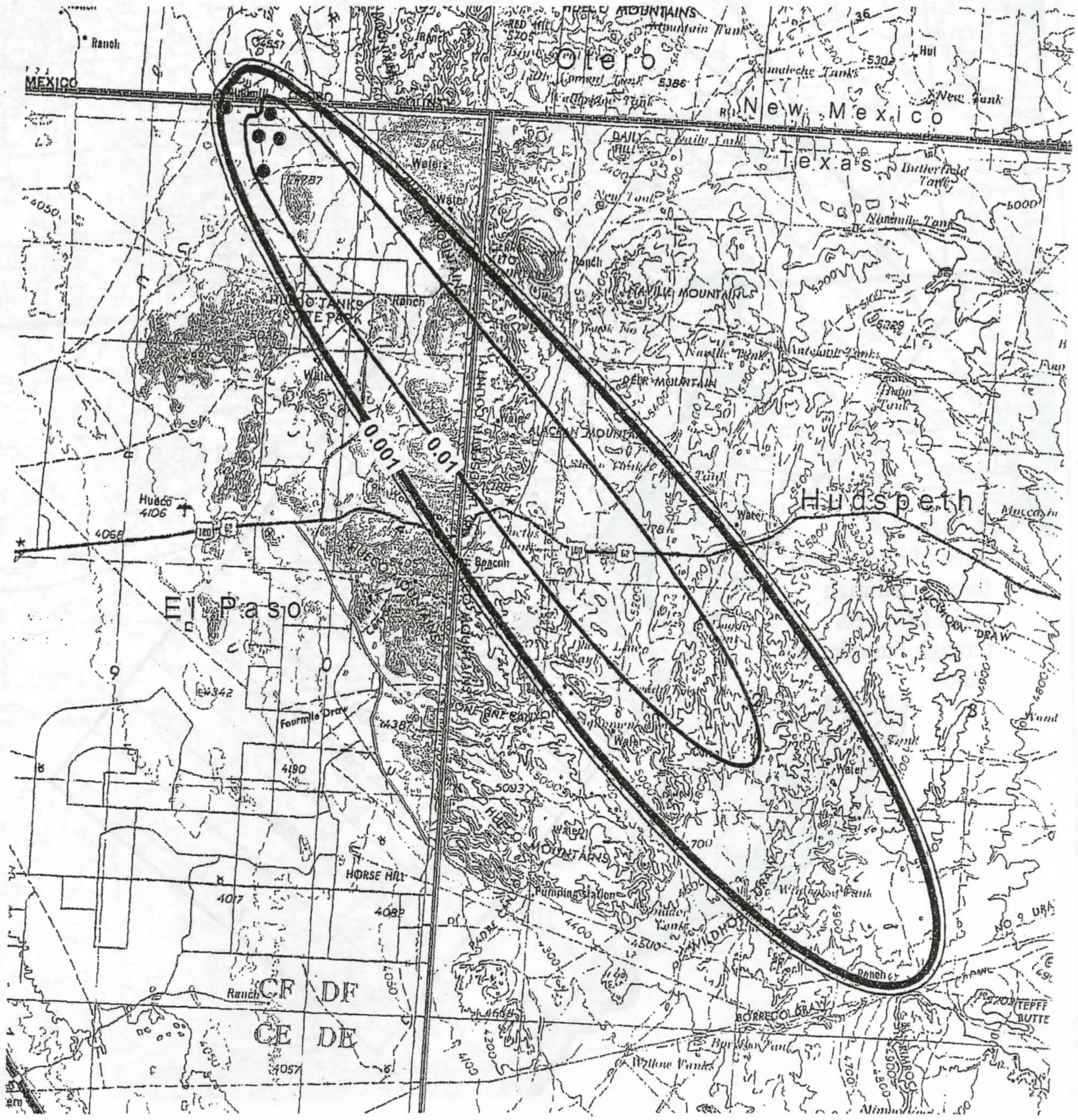
Legend

- Active Injection Wells
- Authorized Injection Wells
- Model Grid Boundary
- Proposed Exempt Area
- Proposed Exempt Area Plus 1/4- Mile Buffer Zone
- Pre-Injection Head contours

STEADY-STATE POTENTIOMETRIC CONTOURS IN THE AQUIFER

FIGURE 11

LBG-GUYTON ASSOCIATES



Legend

- Active Injection Wells
- Authorized Injection Wells
- Proposed Exempt Area
- Proposed Exempt Area Plus 1/4- Mile Buffer Zone
- Relative Concentration after 50 years of Injection

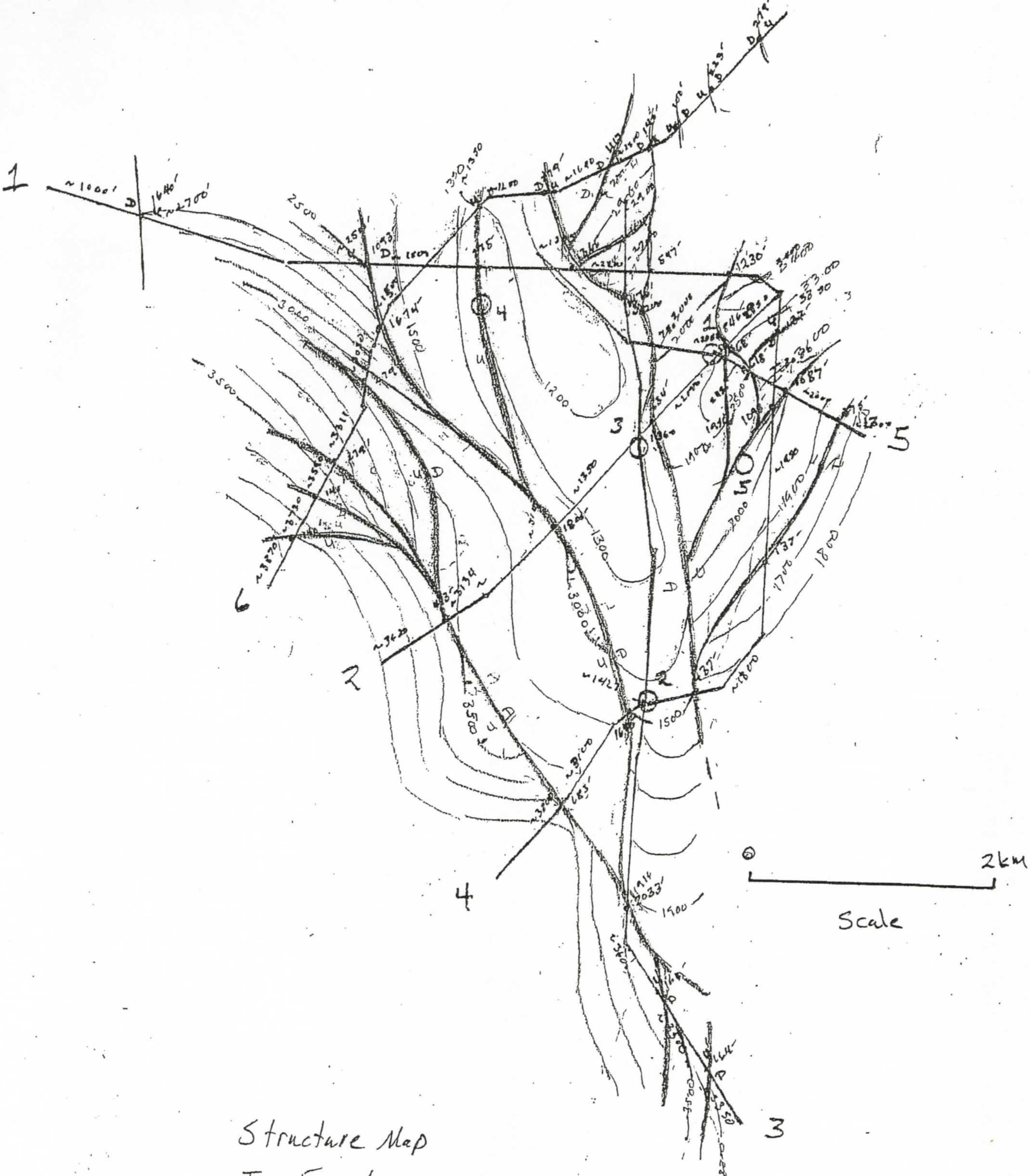
N

0 2.5 5 10 Miles

RELATIVE CONCENTRATION OF INJECTATE AFTER 50 YEARS OF PUMPING

FIGURE 15

LBG-GUYTON ASSOCIATES



Structure Map
Top Fusselman

Based on data from
Granillo, 2004

Murry

DUE DATE ____________

ARTS # 1315 1502

PM BSmith

EL PASO WATER UTILITIES
PUBLIC SERVICE BOARD

EDMUND G. ARCHULETA, P.E.

July 22, 2010

Certified Mail
Return Receipt Requested

Mr. Richard A. Hyde, P.E.
Deputy Director
Office of Permitting and Registration
Texas Commission on Environmental Quality
P.O. Box 13087
Austin, Texas 78711-3087

RADIOACTIVE MATERIALS DIVISION
2010 JUL 28 PM 3 1

Re: EPWU Application for Aquifer Exemption (Treated as a Minor Modification)
Class V Authorization 5X2700062, Tracking No. 12421324-1
CN602957060/RN104809389
Kay Bailey Hutchison Desalination Plant

Dear Mr. Hyde:

As a follow-up to our conversation on June 15, 2010, El Paso Water Utilities (EPWU) staff met with Texas Commission on Environmental Quality's (TCEQ) Underground Injection Control (UIC) staff and have made good progress in clarifying several issues on the proposed aquifer exemption. As a follow-up to their meeting on June 24, 2010, EPWU promised to provide UIC staff with a written response summarizing the discussions held in that meeting. Attachment A of this letter is a document addressing TCEQ's comments and EPWU's response to those comments.

An additional outcome of the June 24th meeting was the realization that defining the area for the proposed aquifer exemption based on the physical coordinates of a modeled concentrate plume would be quite challenging and that it would be more effective to simply place a "box" around the concentrate plume and its one-quarter mile buffer zone, designating this "box" as the proposed exempted area. The revised proposed exempt area, along with replacement figures for the modified application, is included as Attachment B.

We sincerely appreciate the interest you have shown in this project as well as the dedication of the Underground Injection Control Team in the review of this application. We request that the proposed area be designated as the exempt area of the aquifer pursuant to El Paso Water Utilities' petition.

Sincerely,

Ed Ch

Edmund G. Archuleta, P.E.
President/Chief Executive Officer

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SOURCE WATER
PROTECTION BRANCH
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Attachments
cc: Ben Knape, TCEQ

ATTACHMENT A

EPWU Response to TCEQ Comments

EPWU Application for Aquifer Exemption
Response to TCEQ Comments of June 21, 2010

TCEQ Comment: Under the heading titled Groundwater Flow, (pg 19) LBG states that static water level data supports a south to southwesterly flow and groundwater movement to the south can be interpreted by the temperature gradient studies. In the 2008 application, LBG states that static water level data supports a south to southeasterly flow and groundwater movement to the south and southeast can be interpreted by the temperature gradient studies. Please provide the justification for this change in direction.

EPWU Response: The statement on Page 19 of the Revised Aquifer Exemption Application was meant to indicate that the flow direction throughout the region is generally to the south, as opposed to the north. Regional flow in the overlying Hueco-Tularosa alluvial basin is from north to south (EPA, 1997 and Heywood and Yager, 2003). A similar flow direction is to be expected in the underlying bedrock aquifers, such as the Fusselman Formation. Both the shallow alluvial sediments and the underlying bedrock units are part of the same regional groundwater flow system, whether it is fresh or brackish. The overlying alluvium and the underlying bedrock together are classified as a USDW (Underground Source of Drinking Water). Even though there is limited data in the deeper bedrock units, deeper brackish-saline formations, such as the Fusselman, are part of the same regional flow system. This concept of regional flow systems was first developed by Joseph Toth in 1963 (Exhibit 1) and further quantified by Al Freeze and Paul Witherspoon in the late 1960's (Exhibit 2) (Toth, 1963; and Freeze and Witherspoon, 1968). They showed that groundwater flow in deeper bedrock aquifers typically mimics shallow water table (alluvial) aquifers and that the direction of groundwater flow is typically from areas of higher topographic elevation to areas of lower topographic elevation. Major rivers, such as Rio Grande, are the primary zones of regional groundwater discharge. In the El Paso region, groundwater flow in these deeper bedrock units is still expected to be in the same general direction as the overlying alluvium, that is, from New Mexico to the south toward the Rio Grande. Hydraulic gradients in the deeper units are expected to be flatter.

The specific south-southeast direction of flow in the 2008 Aquifer Exemption Application was based on a review of available literature and the test data from the injection site. These data inferred that flow from the injection site would be toward the South/Southeast. This included: 1) the structure map for the area (Exhibit 3), 2) the gravity map for the area (Granillo, 2004) (Exhibit 4), and a thermal map for the area (Witcher, 1997) (Exhibit 5). At the time of the TCEQ review, Mr. David Murray (TCEQ) suggested a gradient toward the southwest, based on water levels in the three wells at the injection site. EPWU was aware of this apparent direction of flow towards the southwest but felt that the geologic data referenced above indicated there was a strong anisotropy (fabric) toward the southeast (Exhibits 3,4, and 5), and therefore the direction of groundwater flow was more toward the southeast. The apparent gradient to the southwest as observed by TCEQ appears to be caused by different water levels in different fault blocks at the injection site. A more regional perspective, however, indicated a southeast flow direction.

Mr. Murray also made the observation that the Fusselman Formation outcropped along the east side of the Hueco Mountains (to the southeast of the injection site), and might be a possible area for Fusselman groundwater discharge. Because of the questions raised by TCEQ, EPWU reevaluated the direction of flow in a more regional context. This reinterpretation included a mapping of the Fusselman Formation in the Hueco Mountains (Figure 2, 2008 Revised Aquifer

Exemption Application). This provided a more detailed structural map of the Fusselman for the groundwater model. This mapping indicated that the Fusselman in the area of the Hueco Mountains was eroded away and no longer existed. In the geologic past, the area had been uplifted and was now part of an eroded anticlinorium. This lack of Fusselman in the Hueco Mountains creats an area of "no flow" in the southeast part of the groundwater model. When the revised distribution of the Fusselman was input into the MODFLOW model, the regional direction of groundwater flow shifted. Because of this no flow section of the aquifer, groundwater flow in the Fusselman is now toward the south (Exhibit 6). This southerly direction of both the regional flow and the anticipated injectate plume direction parallels the groundwater flow direction in the overlying Hueco-Tularosa alluvial aquifer, as modeled by the U.S. Geological Survey (Exhibit 7, Heywood and Yager, 2003). This more regional perspective is considered more realistic.

TCEQ Comment: **Under the heading titled "Conceptual Model" (pgs. 21 – 23), EPWU states that a groundwater flow direction of south was assumed for groundwater flow in the injection zone. This assumption was based on a similar flow direction for groundwater in sediments of the overlying Hueco-Tularosa Aquifer, as described in an EPA document. The TCEQ is unsure of the validity of this assumption for two reasons. First, the injection zone dips west, as is illustrated on Figure 17. Second, units of the injection zone crop out to the east in the Hueco Mountains (Figure 5), providing an area of recharge for the injection interval. These two features would favor a westward direction for groundwater flow. Please provide additional information to support a southward groundwater flow direction in the units of the injection zone.**

EPWU Response: We agree that the Fusselman Formation beneath the eastern side of the Hueco Bolson dips to the west. Geologic structure may play a role in the flow direction of groundwater, however, this is not the primary determinant for the direction of groundwater flow. As noted in *Groundwater* (Freeze and Cherry, 1979), groundwater flows from higher "total potential" to lower "total potential." Regional flow in the overlying Hueco-Tularosa alluvial basin is from north to south (Heywood and Yager, 2003). A similar flow direction is to be expected in the underlying bedrock aquifers, such as the Fusselman Formation. The geologic section, from the shallow alluvial sediments to the underlying bedrock units, are part of the same regional groundwater flow system. A more detailed discussion of this topic is included above in EPWU's response to the first comment.

Regarding TCEQ's comment about geologic units of the injection zone cropping out in Hueco Mountains, the Fusselman Formation crops out on the eastern side of the Hueco Mountains (Figure 8), that is, on the east side of the eroded anticline, and not on the west. Potential recharge of the Fussleman on the east side will flow to the east toward the Dell City area. This is documented in several scientific publications, including "Hydrogeology of the Diablo Plateau, Trans-Pecos, Texas," (Kreitler, Mullican and Nativ, 1990) which showed that the regional groundwater flow in the Diablo Plateau is to the east. Recharge to the Fusselman where it crops out on the eastern side of the Hueco Mountains is not expected to have any impact on groundwater flow in the Fussleman on the west side of the Huecos. On the west side of the Hueco Mountains, the Fusselman is not present as surface outcrop (Barnes, 1968). We do not expect any recharge of the Fussleman on the western side of the Hueco Mountains, because the Fussleman does not crop out on the western side.

TCEQ Comment: **Under the heading titled "Conceptual Model" (pgs. 21 – 23), EPWU states that the assumed groundwater gradient in the injection zone was 0.003 ft/ft, based in part on the groundwater gradient in the Hueco-Tularosa Aquifer, as reported in an EPA document. The TCEQ is unsure as to how this gradient was determined. It is the TCEQ's understanding that except for water level data from the three injection wells at the site, EPWU has no other groundwater level data for the area that was modeled. Given the size of the area modeled, the TCEQ is not convinced the groundwater gradient in the modeled area is valid. Please provide additional information to support the assumed gradient for the modeled area.**

EPWU Response: The hydraulic gradient was determined by measuring head difference over a given distance based on potentiometric maps developed from regional water level measurements. In this case, the maps were from the EPA publication "Transboundary Aquifers of the El Paso/Ciudad Juarez/Las Cruces Region" (1997). The estimated hydraulic gradient is conservative and still indicative of the regional flow in the shallower Hueco-Tularosa system. Based on findings from other regional systems, we feel it is appropriate to use the regional gradient and general flow direction for the deeper units such as the injection zone.

EPWU also refers TCEQ to *Groundwater* (Freeze and Cherry, 1979), which indicates how topography and hydrogeology can impact regional flow systems. Toth (1963) indicates that deeper units in regional flow systems generally have similar but lower hydraulic gradients than the shallower units in the same system. Relevant figures from Freeze and Cherry are included as Exhibits 1 and 2.

TCEQ Comment: **Under the heading titled "Model Development and Calibration" (pgs 24-25), EPWU states that the boundary conditions set for the model reproduced the observed water levels at the site. Therefore, model calibration appears to be based only on water levels in the three injection wells, which are in a small portion of the total area modeled. No other information was provided with regards to model calibration in other parts of the area modeled. The TCEQ does not agree that water level data from these three relatively closely spaced wells provides sufficient information for adequate calibration of the model, given the size of the area modeled. Please provide additional information for model calibration or please explain why no additional information is necessary for adequate model calibration.**

EPWU Response: We agree with TCEQ that the three local water level measurements only represent a small portion of the system, therefore, EPWU also relied on regional measurements to calibrate the model. As discussed in the response to previous comments, the model calibration was based both on the water levels in the three injection wells as well as regional water level measurements (from EPA, 1997) and the inferred hydraulic gradients from those measurements.

TCEQ Comment: **Under the heading titled "Assessment of Vertical Plume Movement" (pgs. 27 – 29), LBG states that the area that experiences 1.0 foot or more of head pressure is 17,088 acres whereas previously stated (2008) it was 4,750 acres. Please justify the difference.**

EPWU Response: The statement in the revised application (April 2010) is correct. The area that experiences 1.0 foot or more of head pressure is 17,088 acres. The 2008 application reflects an administrative typographical error.

References

Barnes, U., 1968, Geologic Atlas of Texas Van Horn-El Paso Sheet, The Univeristy of Texas at Austin, Bureau of Economic Geology.

Freeze, A. and Cherry, J., 1979, Groundwater, Prentice Hall, 604 p.

Freeze, A. and Witherspoon, P., 1968, Theoretical analysis of regional groundwater flow: Quantitative interpretations, Water Resources Research, v.4, p. 581-590.

Granillo, J., 2004, A gravimetric study of the structure of the northeast portion of the Hueco Bolson, Texas employing GIS technology, University of Texas at El Paso Dissertation, 127 p.

Heywood, C.F., and Yager, R.M., 2003, Simulated groundwater flow in the Hueco Bolson, an alluvial aquifer system near El Paso, Texas, U.S. Geological Survey, Water Resources Investigations Report 02-4108, 74 p.

Kreitler, C., Mullican, W., and Nativ, R., 1990, Hydrogeology of the Diablo Plateau in Kreitler, C. and Sharp, J. (ed) Hydrogeology of Trans-Pecos Texas, The University of Texas at Austin, Bureau of Economic Geology Guidebook 25, p. 49-58.

Toth, J., 1963, A theoretical analysis of groundwater flow in small drainage basins, J. Geophysical Research, v 68, p. 4795-4812.

U.S. Environmental Protection Agency, 1997, Transboundary aquifers of the El Paso/Cuidad/Las Cruces Region, 148 p.

Witcher, J.C., 1997, Geothermal Resource Potential of McGregor Range, New Mexico, New Mexico State University, Southwest Technology Development Institute, GEO 97-5, 26 p.

I, Brad L. Cross, Associate, certify under penalty of law that this document was prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluation the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature Brad L Cross Date July 23, 2010

STATE OF TEXAS
BRAD L. CROSS
GEOLOGY
No. 1401
LICENSED
PROFESSIONAL GEOSCIENTIST

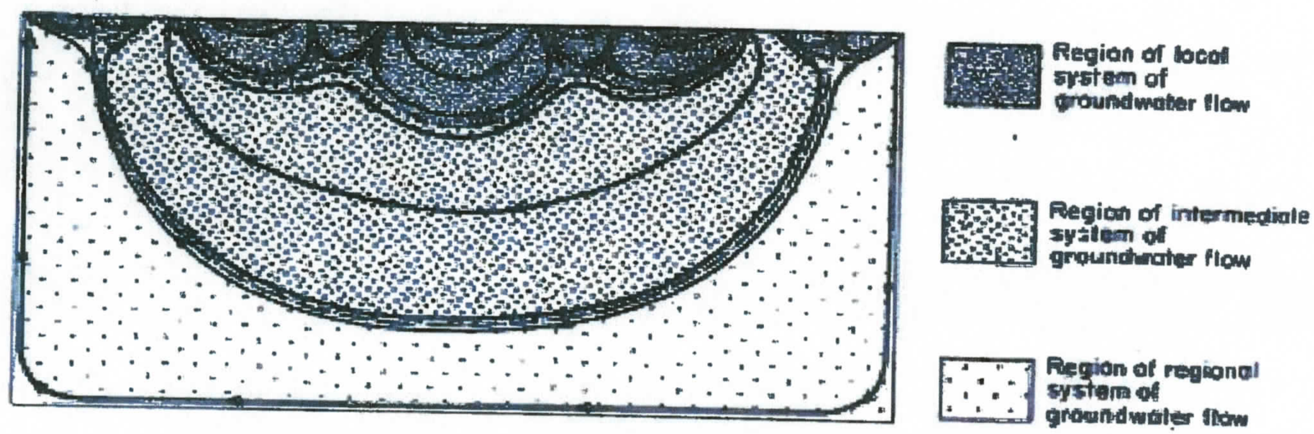


Exhibit 1 – Local, Intermediate and Regional Groundwater Flow (after Toth, 1963)

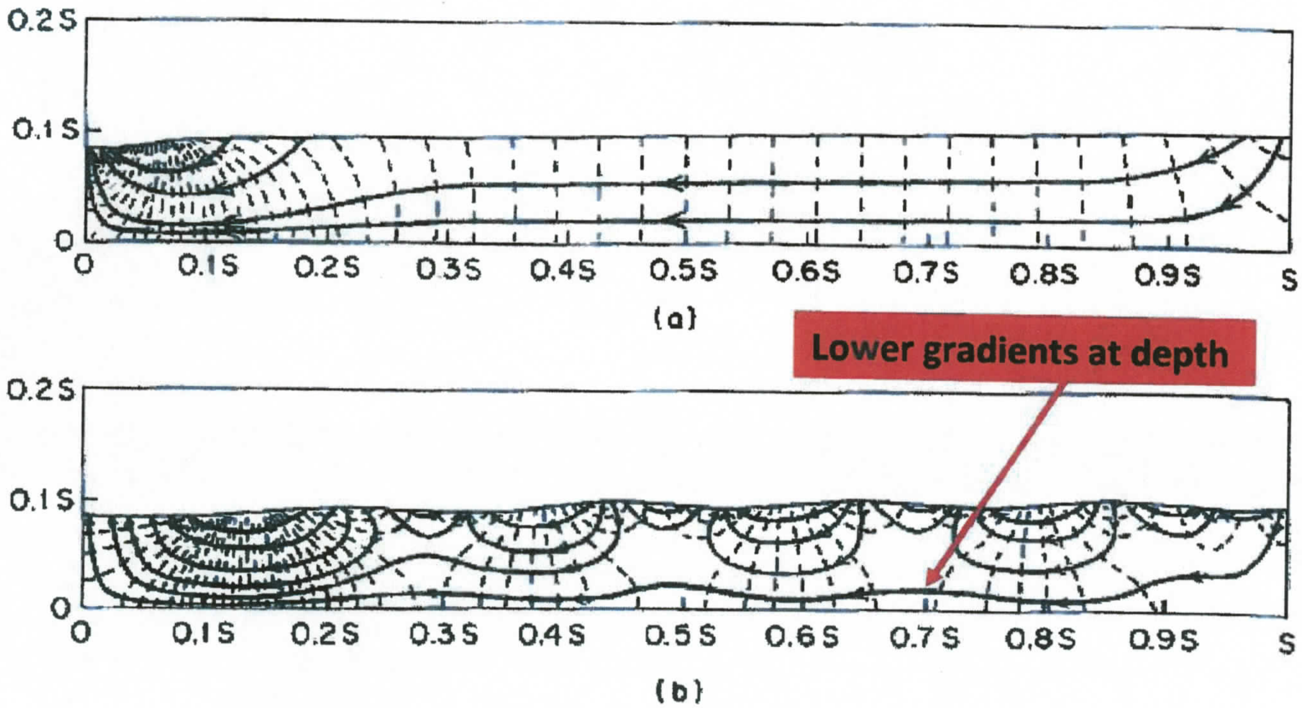


Exhibit 2 – Effect of topography on regional groundwater flow patterns (after Freeze and Witherspoon, 1967)

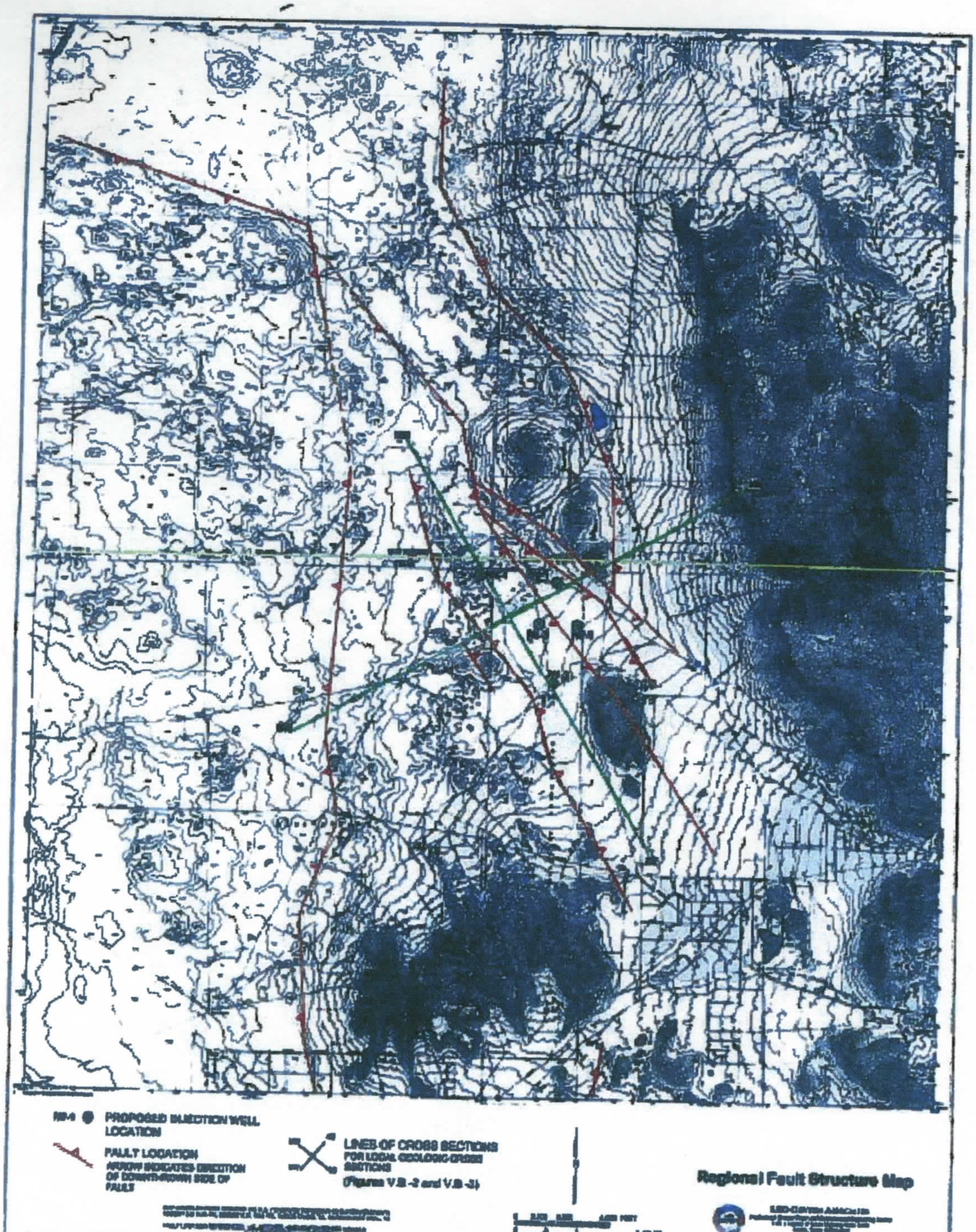


Exhibit 3 – Fault structure map - injection well site area

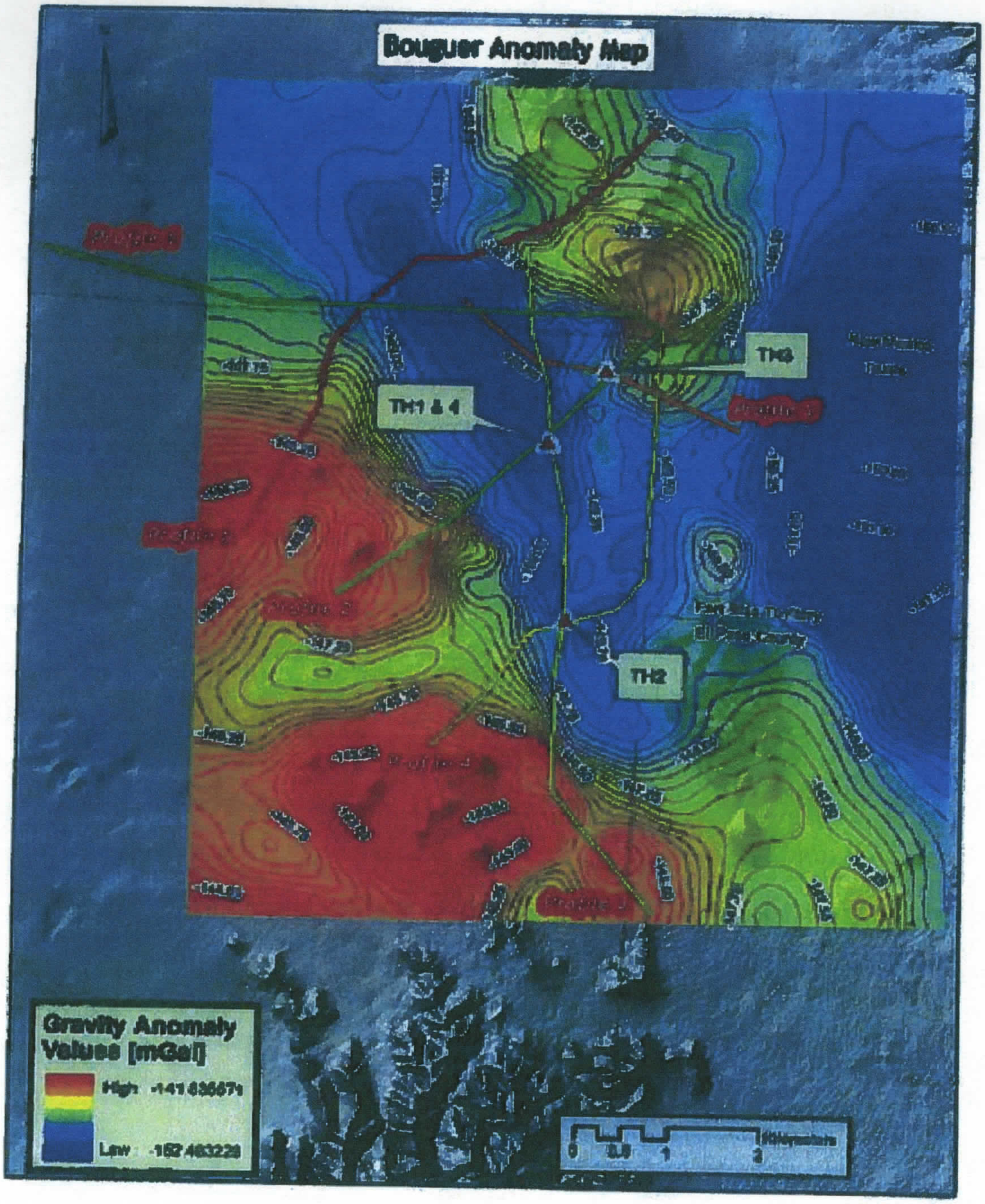


Exhibit 4 – Bouger anomaly map - injection site area (from Granillo, 2004)

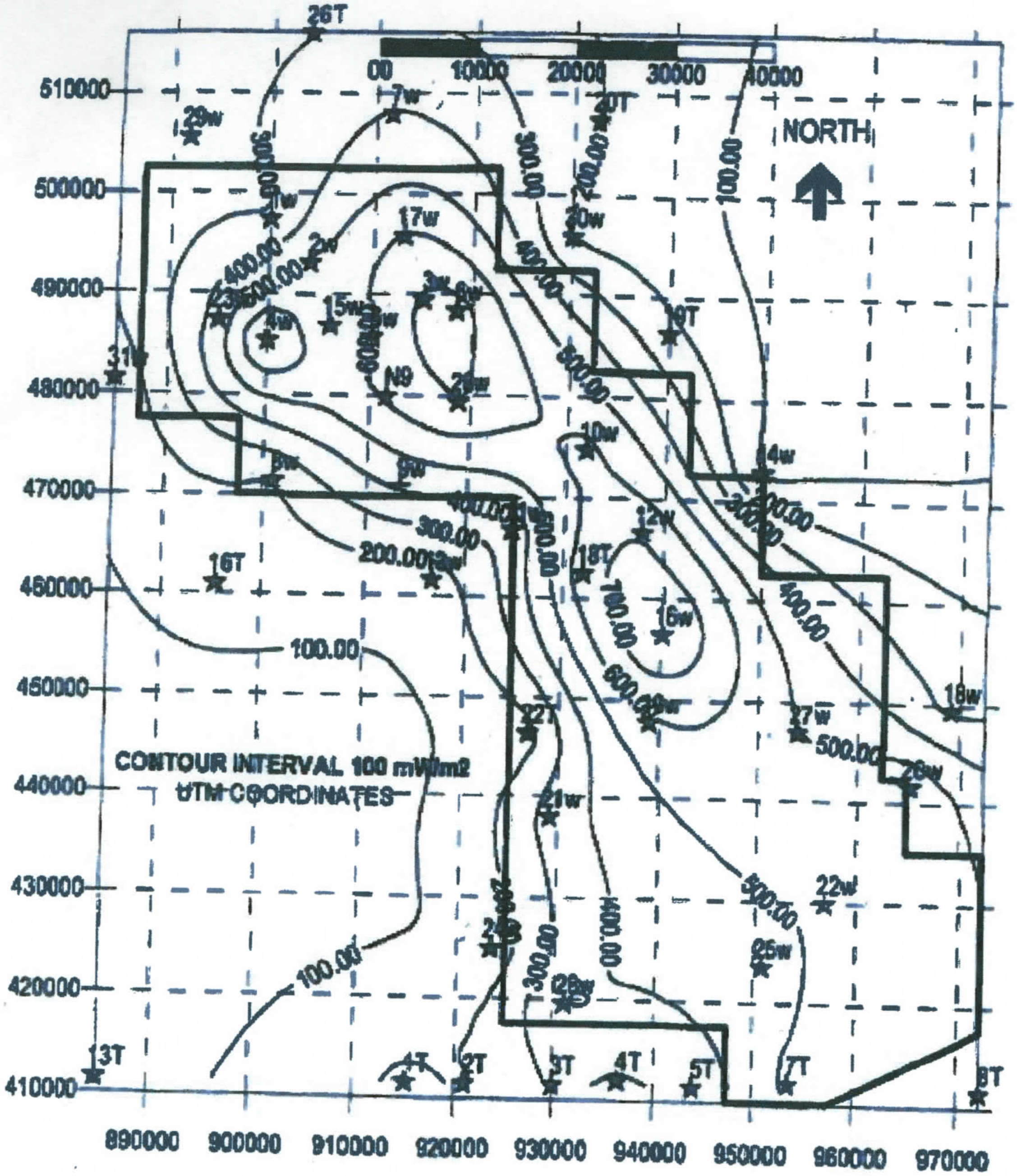


Exhibit 5 – McGregor Range heat flow map (Witcher, 1997)

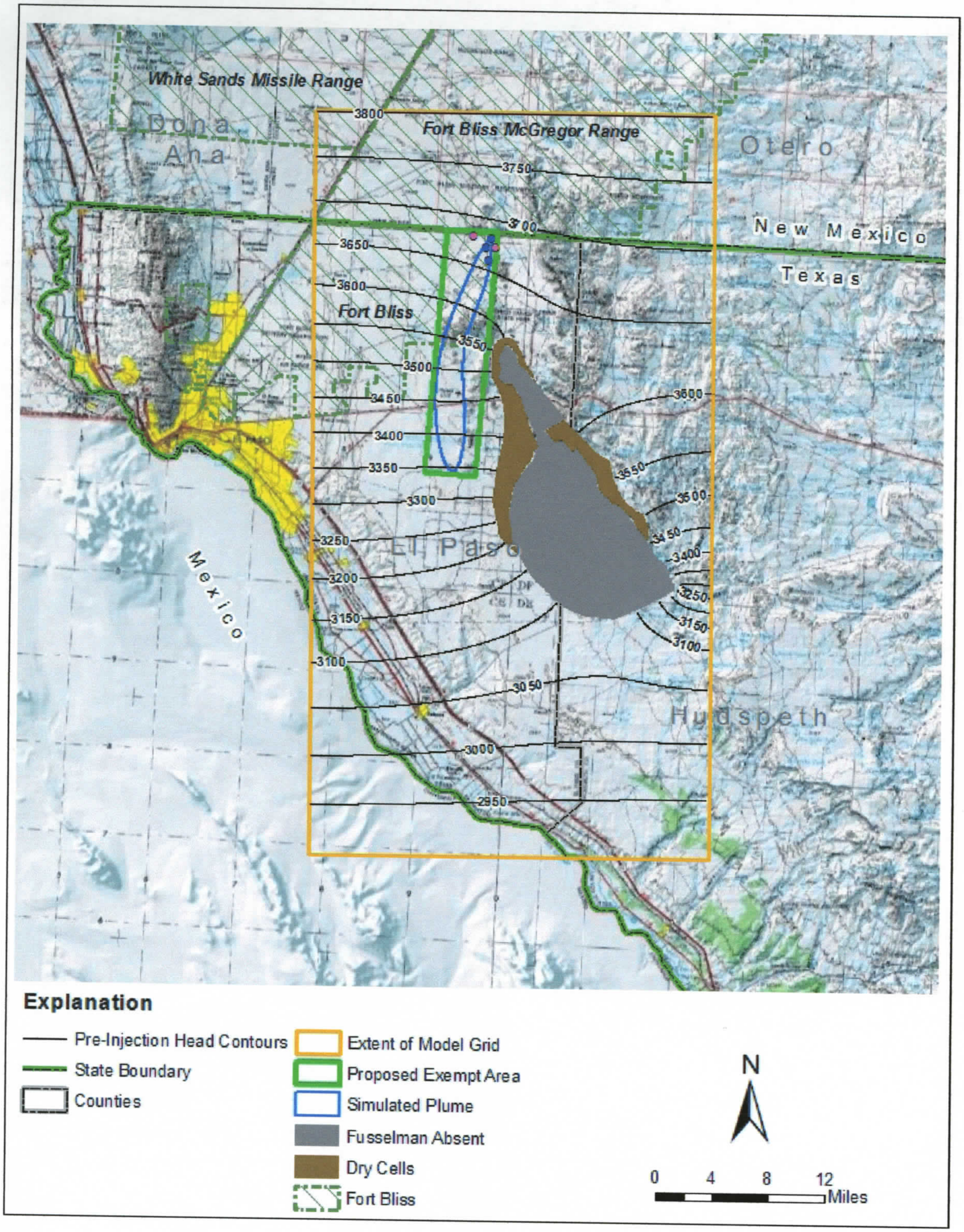


Exhibit 6 – Steady-state potentiometric contours

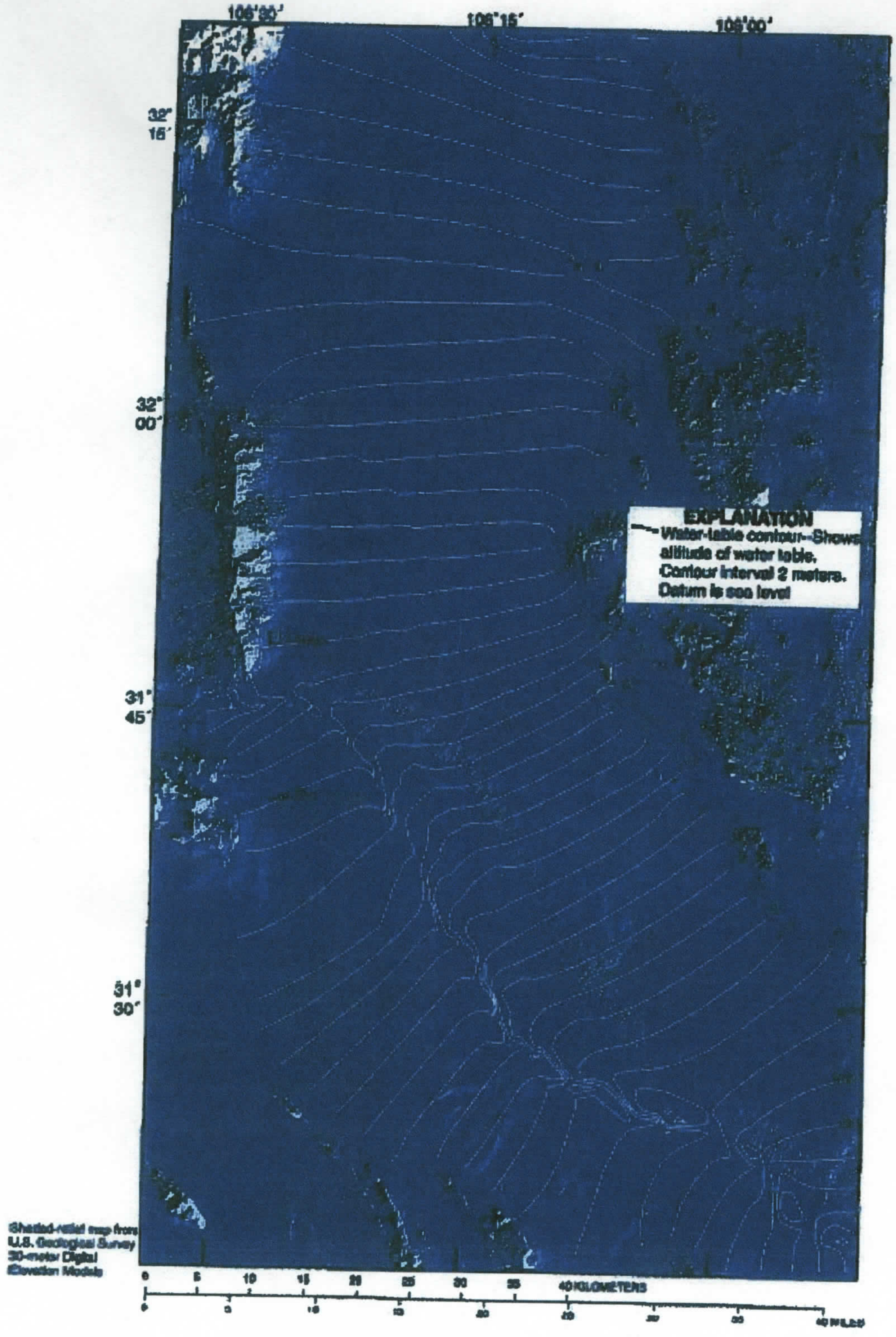
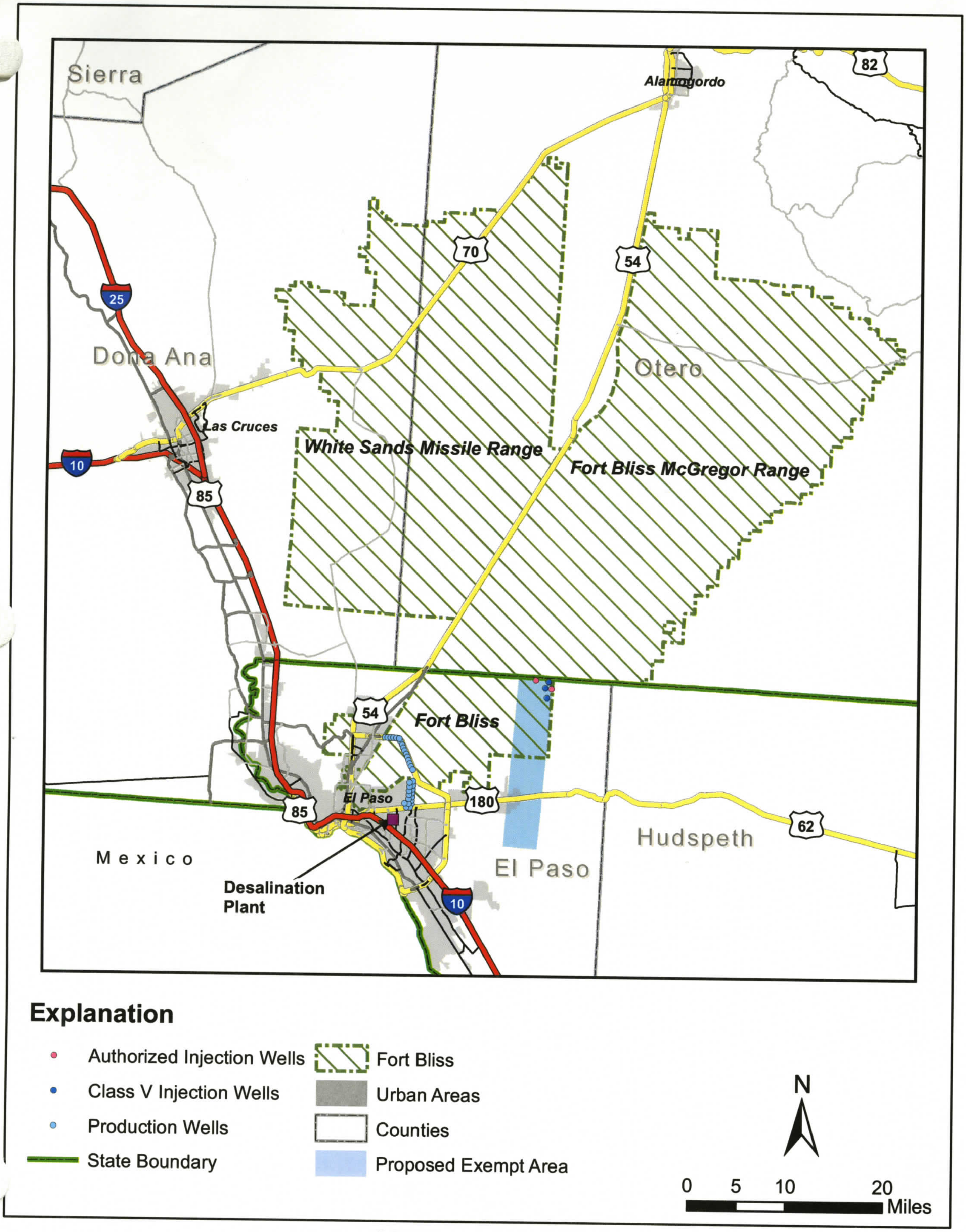


Exhibit 7 – Simulated water table in shallow aquifer (model layers 1 and 2) in 1902 (steady-state conditions)

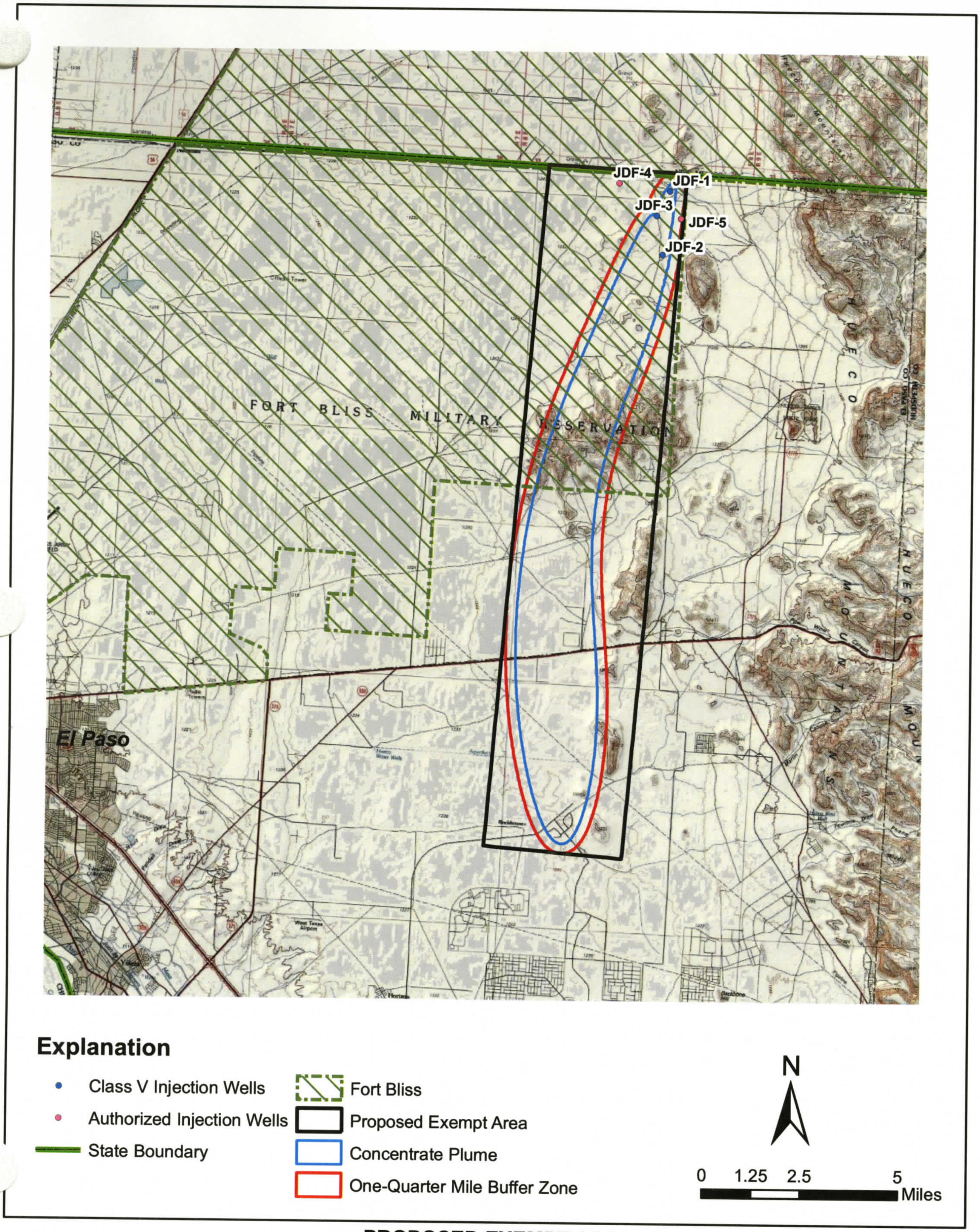
ATTACHMENT B

Proposed Exempt Aquifer
(Revised Figures of April 2010 Aquifer Exemption Application)



GENERAL LOCATION MAP **FIGURE 1**

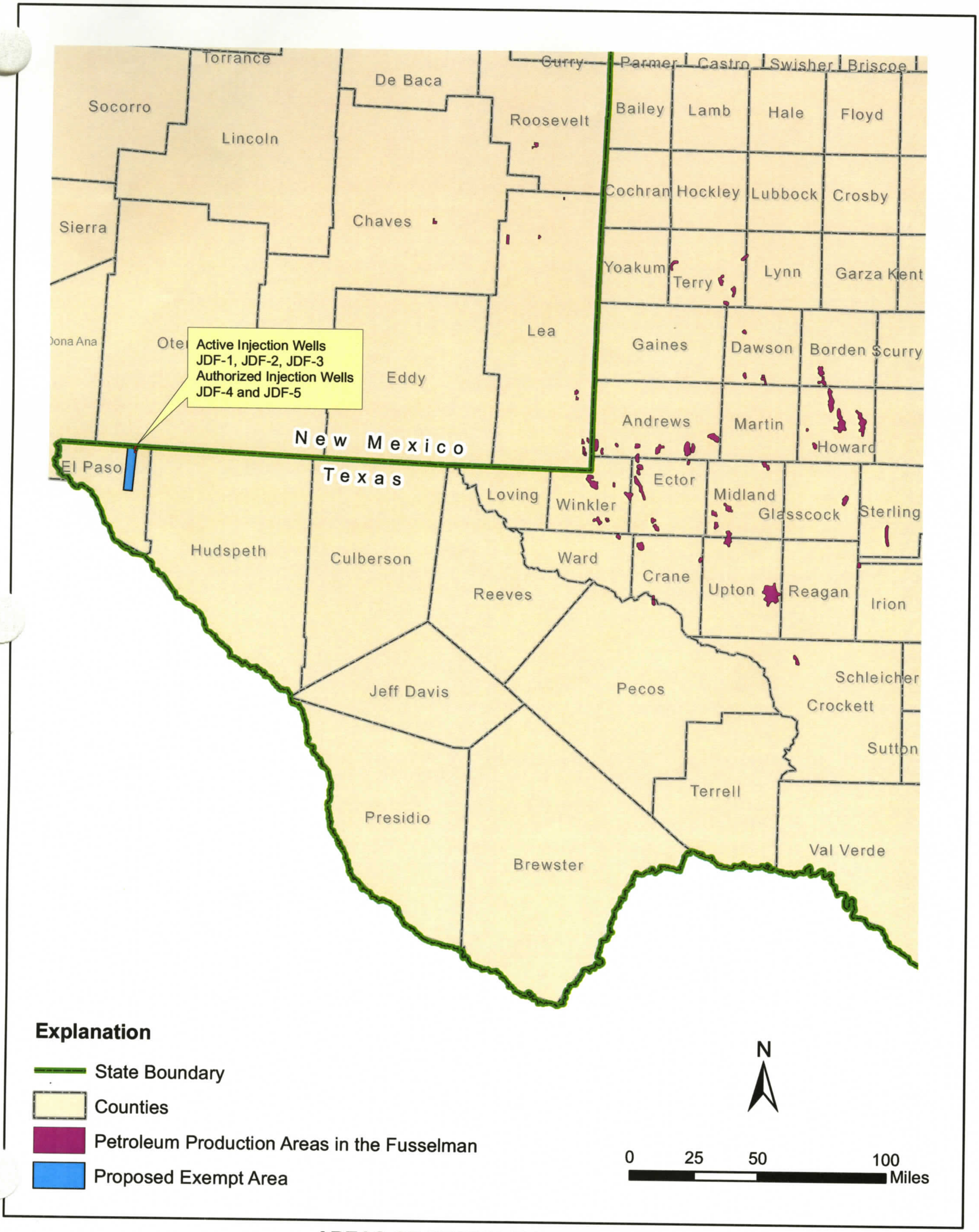
LBG-GUYTON ASSOCIATES



PROPOSED EXEMPT AREA

FIGURE 2

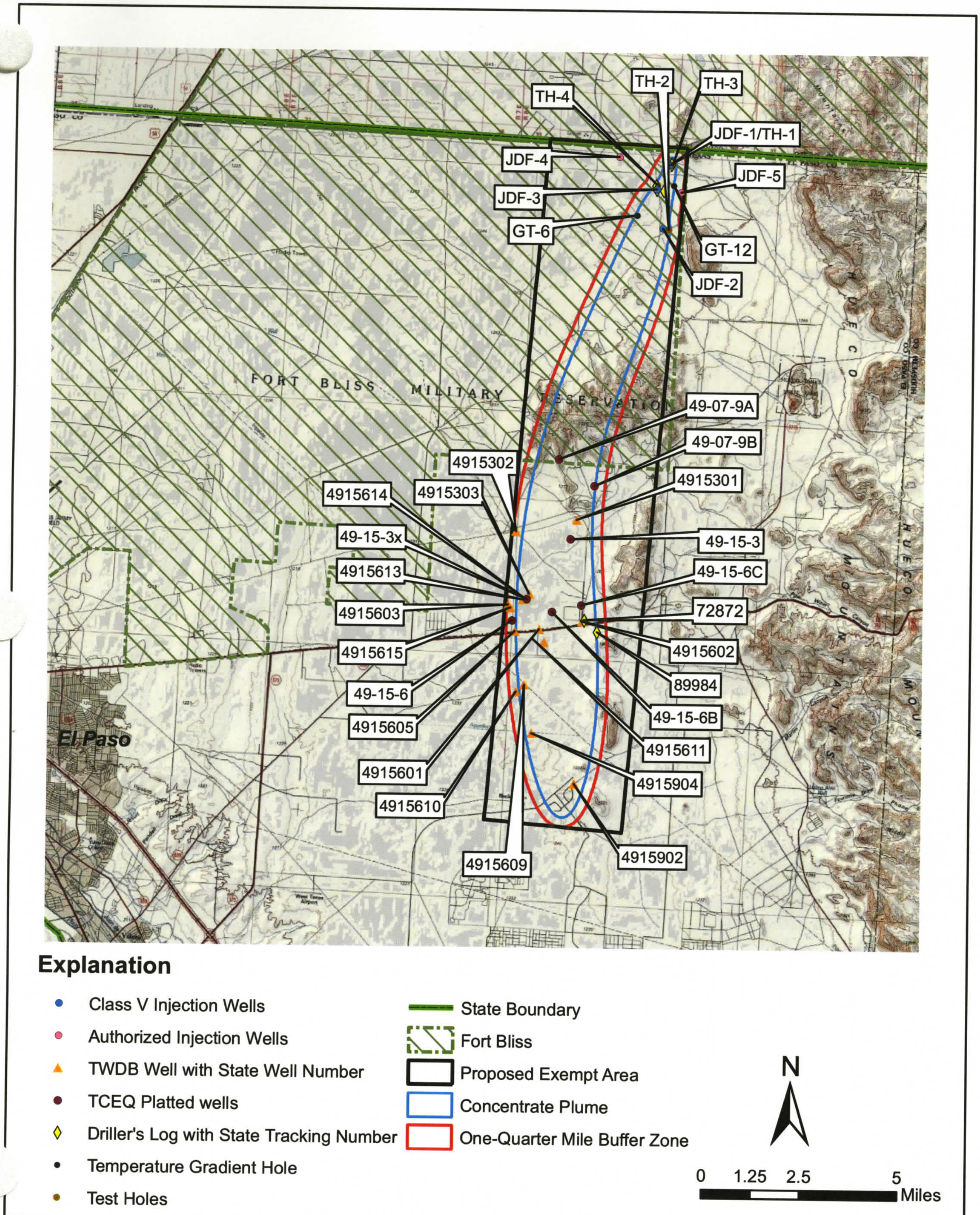
LBG-GUYTON ASSOCIATES



AREAS OF PETROLEUM PRODUCTION IN THE FUSSELMAN

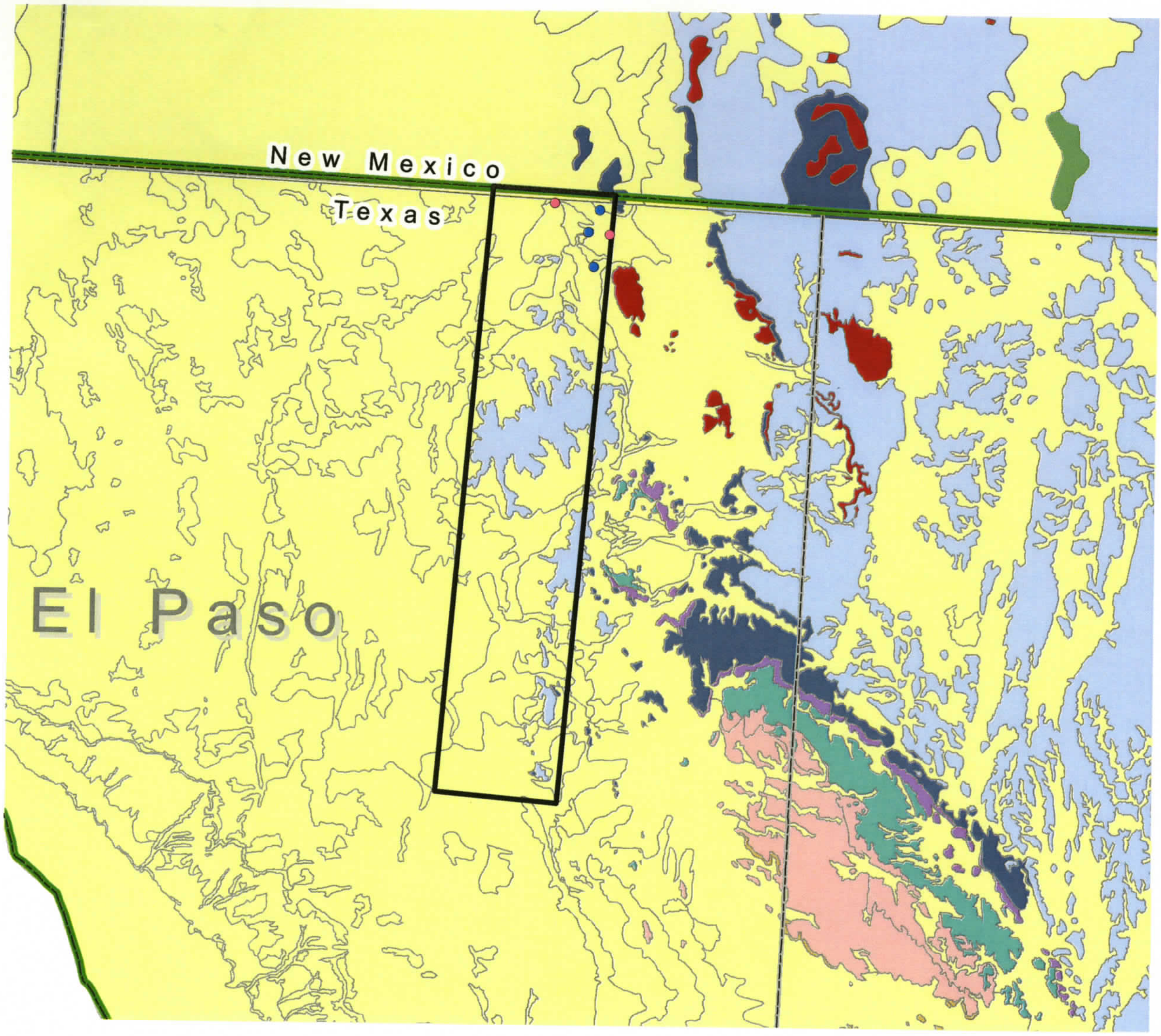
FIGURE 3

LBG-GUYTON ASSOCIATES



ARTIFICIAL PENETRATIONS IN AREA OF REVIEW **FIGURE 4**

LBG-GUYTON ASSOCIATES



Explanation

- Authorized Injection Well
- Active Injection Wells
- State Boundary
- Proposed Exempt Area
- County Boundary

GEOLOGIC UNIT BY AGE

- Quaternary and Tertiary Bolson and Alluvial Deposits
- Tertiary Igneous
- Cretaceous
- Permian
- Pennsylvanian
- Mississippian and Devonian
- Silurian
- Ordovician
- Precambrian

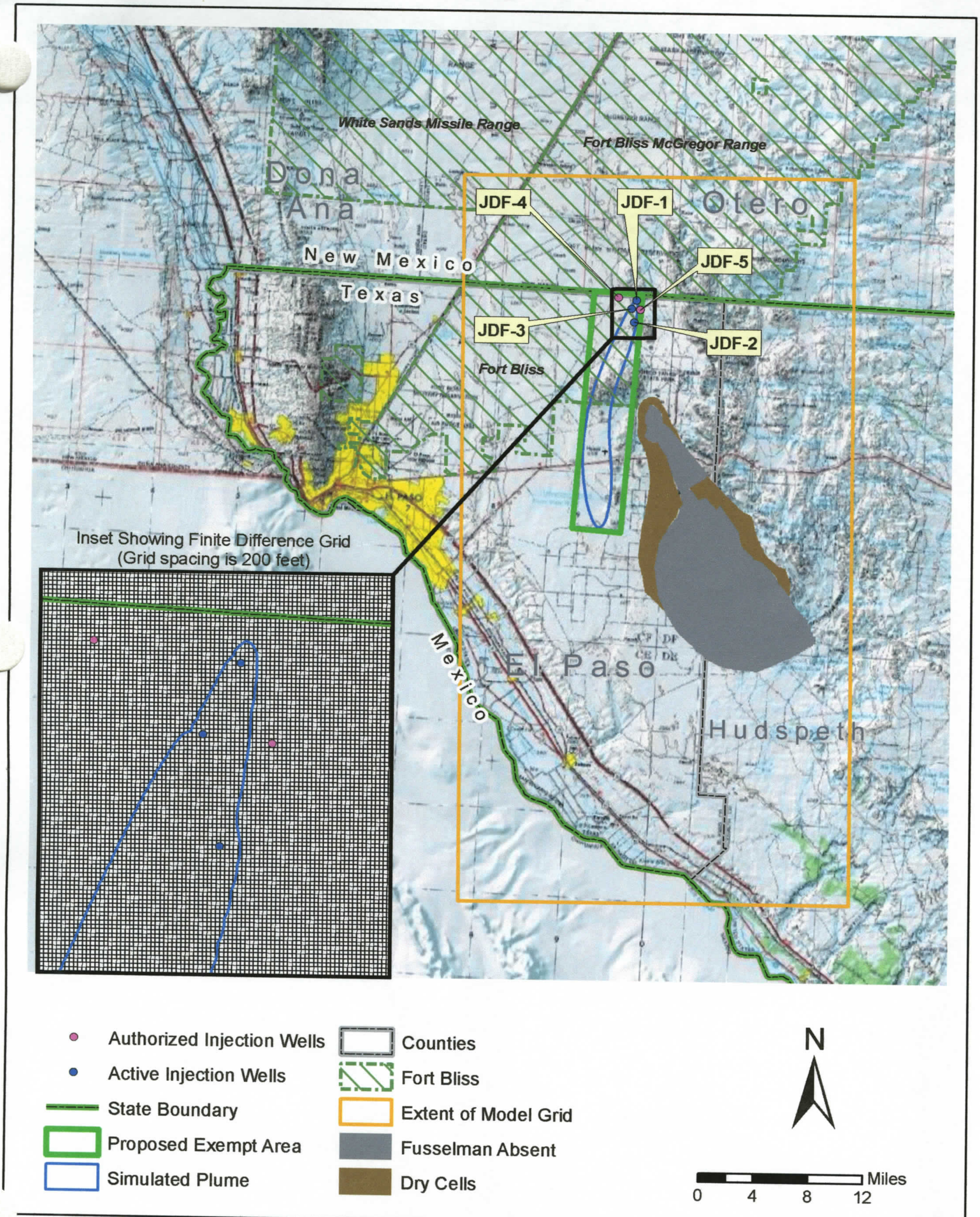
N

0 2.5 5 10 Miles

REGIONAL GEOLOGIC MAP

FIGURE 5

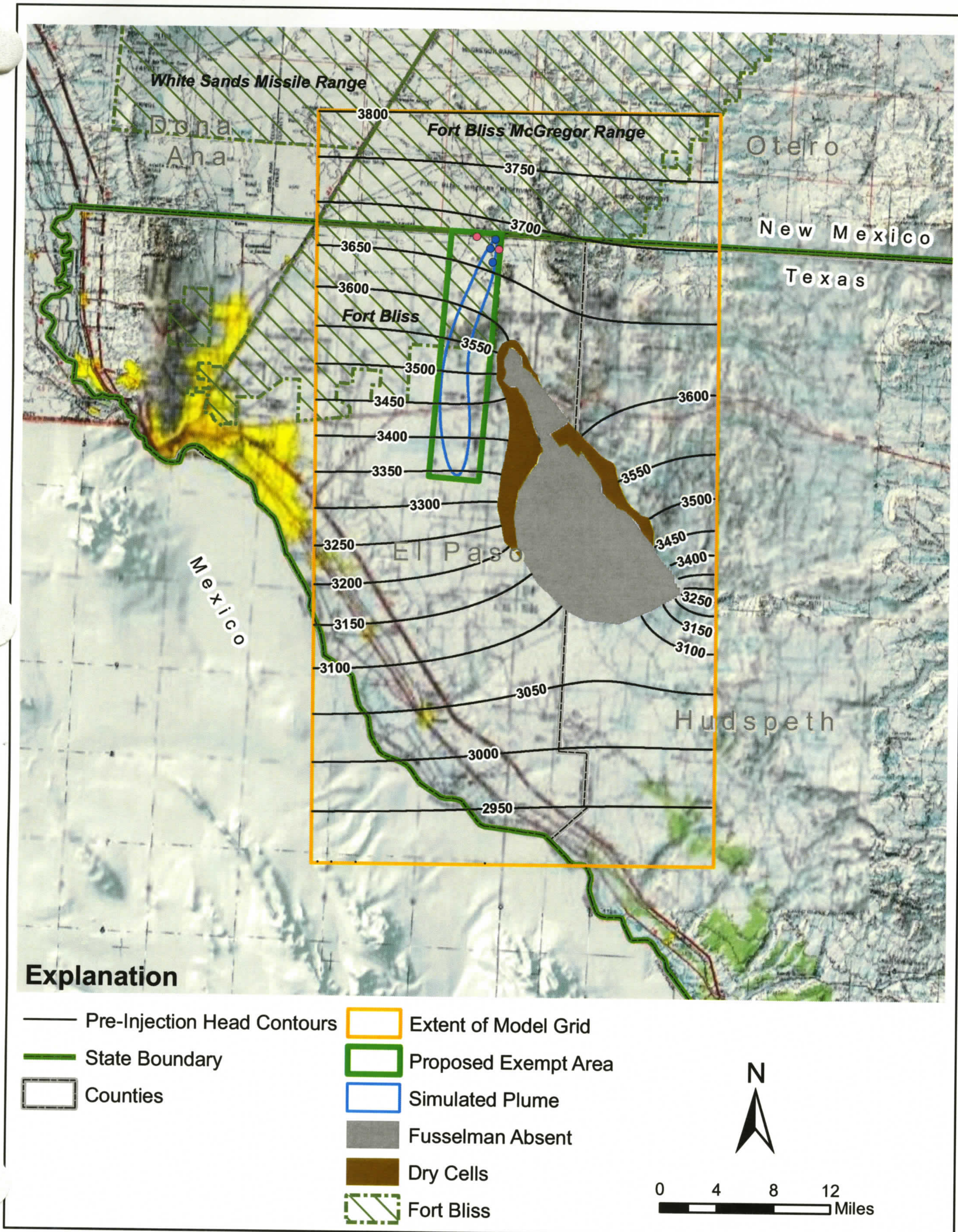
LBG-GUYTON ASSOCIATES



FINITE-DIFFERENCE MODEL GRID USED FOR FLOW AND TRANSPORT MODELING

FIGURE 18

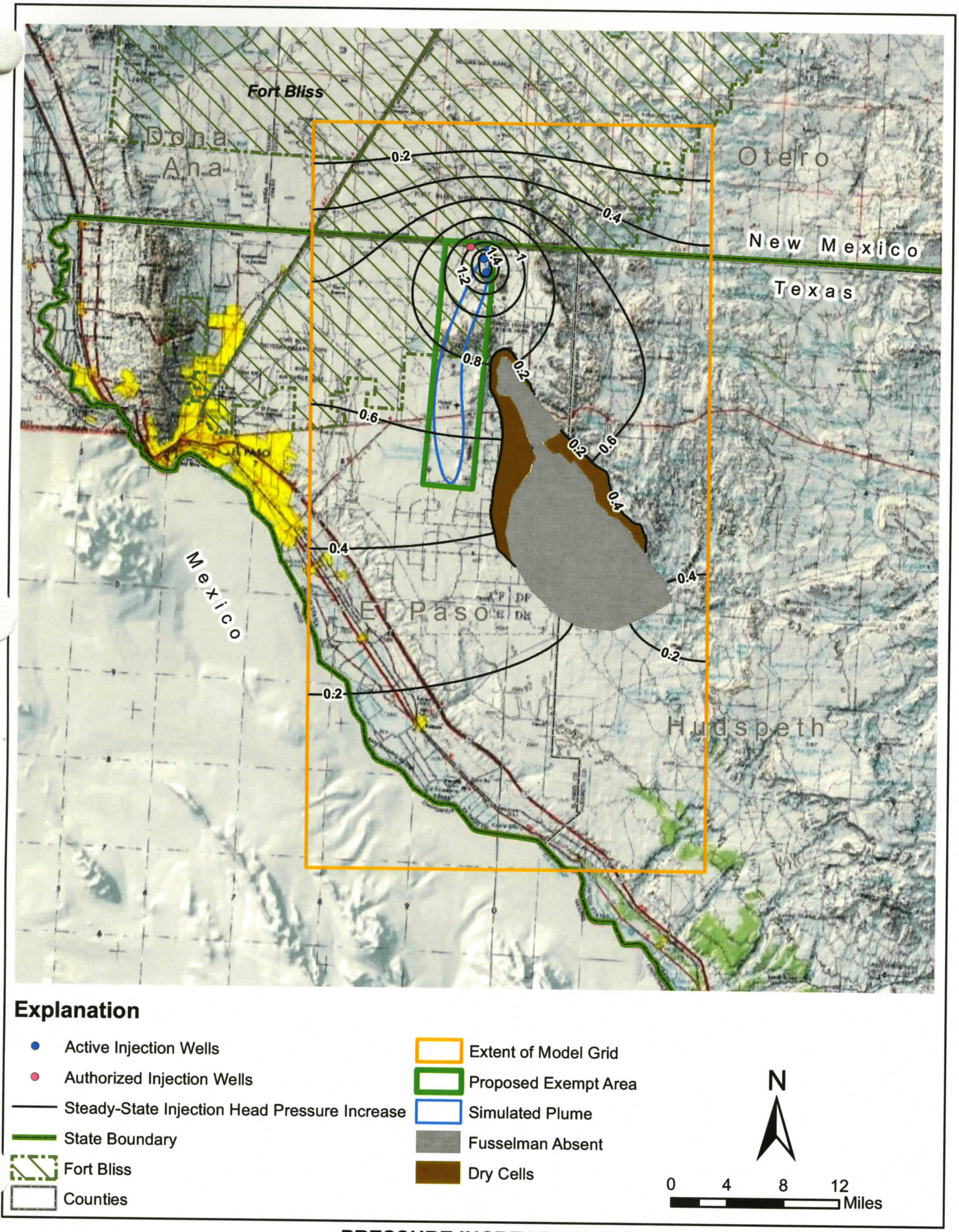
LBG-GUYTON ASSOCIATES



STEADY-STATE POTENTIOMETRIC CONTOURS IN THE AQUIFER

FIGURE 19

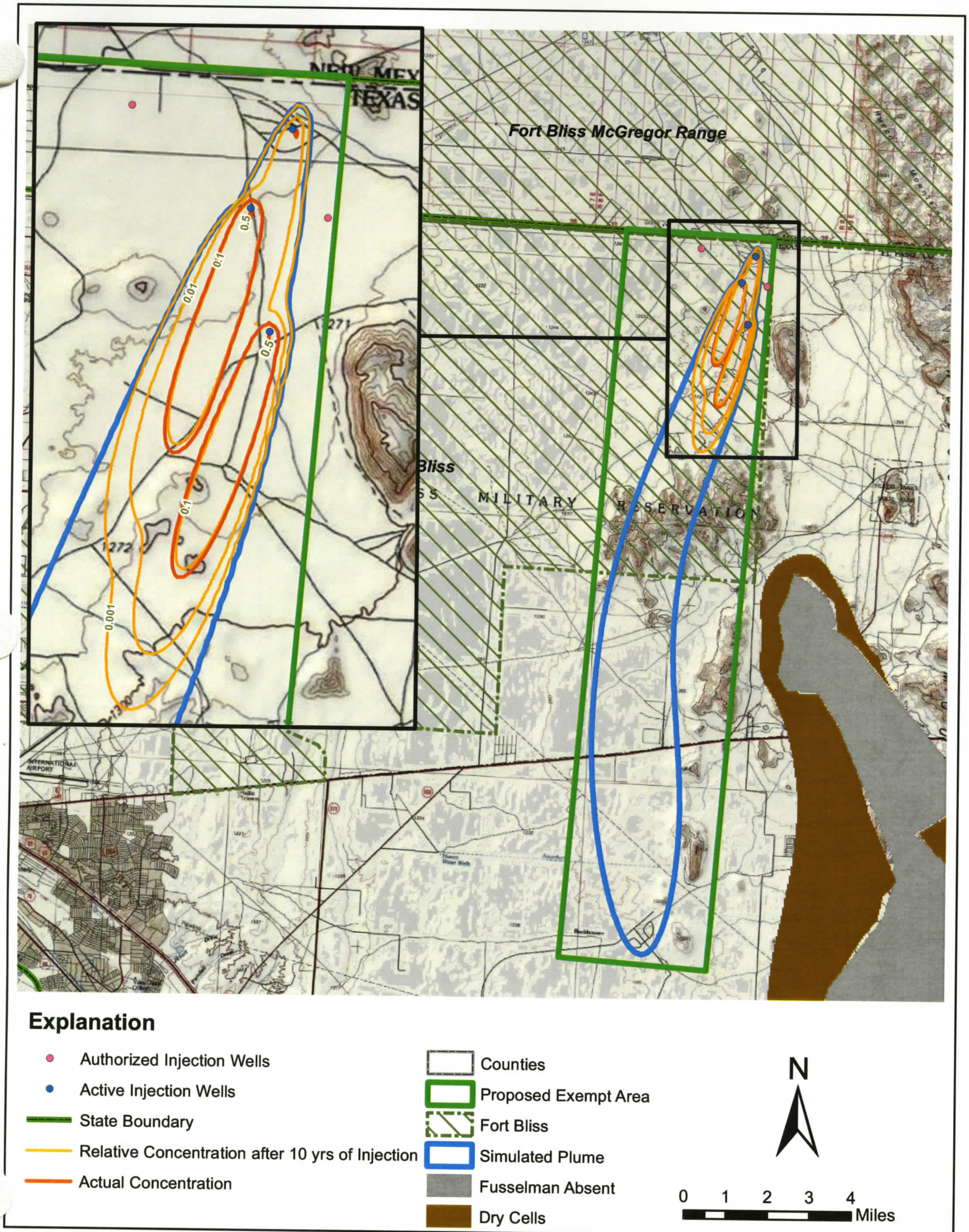
LBG-GUYTON ASSOCIATES



PRESSURE INCREASE (FEET)
AFTER 50 YEARS OF INJECTION

FIGURE 20

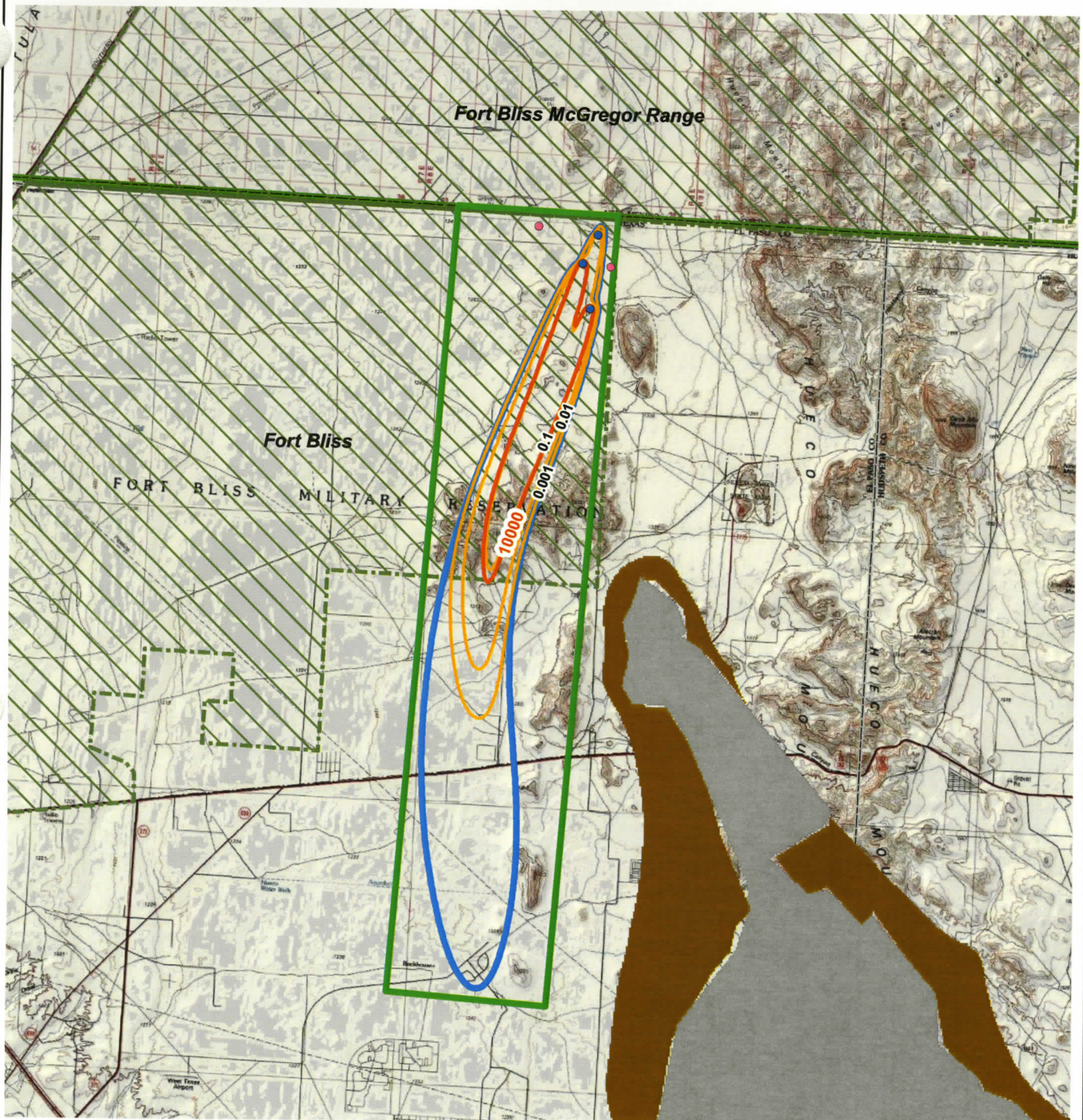
LBG-GUYTON ASSOCIATES



RELATIVE CONCENTRATION OF INJECTATE AFTER 10 YEARS OF INJECTION

FIGURE 21

LBG-GUYTON ASSOCIATES



Explanation

- Authorized Injection Wells
- Active Injection Wells
- Relative Concentration after 30 yrs of Injection
- Actual Concentration
- State Boundary
- Counties
- Proposed Exempt Area
- Simulated Plume
- Fort Bliss
- Fusselman Absent
- Dry Cells

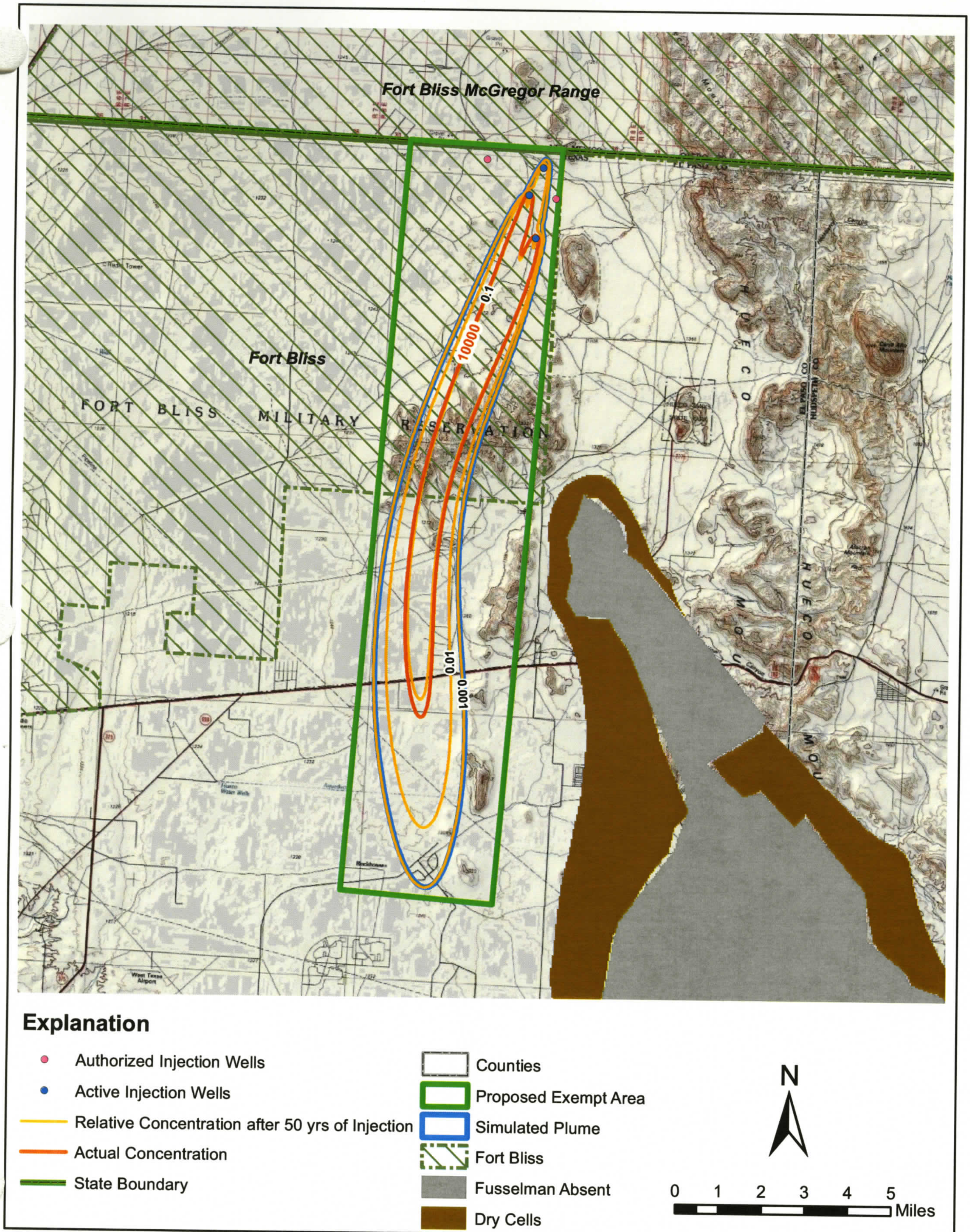
N

0 1 2 3 4 5 Miles

RELATIVE CONCENTRATION OF INJECTATE AFTER 30 YEARS OF INJECTION

FIGURE 22

LBG-GUYTON ASSOCIATES



RELATIVE CONCENTRATION OF INJECTATE AFTER 50 YEARS OF INJECTION

FIGURE 23

LBG-GUYTON ASSOCIATES

I, Brad L. Cross, Associate, certify under penalty of law that this document was prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluation the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature Brad L. Cross Date ___July 23, 2010___

STATE OF TEXAS
BRAD L. CROSS
GEOLOGY
No. 1401
LICENSED
PROFESSIONAL GEOSCIENTIST

Bryan Smith - EPWU Revised Aquifer Exemption

From: "Brad Cross" <BCross@lbg-guyton.com>
To: <bssmith@tceq.state.tx.us>
Date: 8/9/2010 9:48 AM
Subject: EPWU Revised Aquifer Exemption
Attachments: 2 mile buffer exent.pdf

Good Morning Bryan,

Thanks for the phone call Friday afternoon! We really appreciate you working with us on coming up with a proposed exempt area that works for everyone. After speaking with you, I contacted EPWU and after lengthy discussion, we felt that perhaps extending the proposed boundary two miles beyond the outer limit of the plume would provide EPWU with a conservatively designated exempt area. We feel quite confident in the modeled plume boundary but adding an additional two mile buffer zone certainly provides an adequate conservative approach.

This is not an official submittal to TCEQ, simply a draft for you and David to look over and provide unofficial feedback on. Timely feedback on your thoughts and comments would be greatly appreciated. As I mentioned, we have a meeting scheduled with NMED on August 23 and would like to provide them with a better handle on what the proposed area is at this point in time.

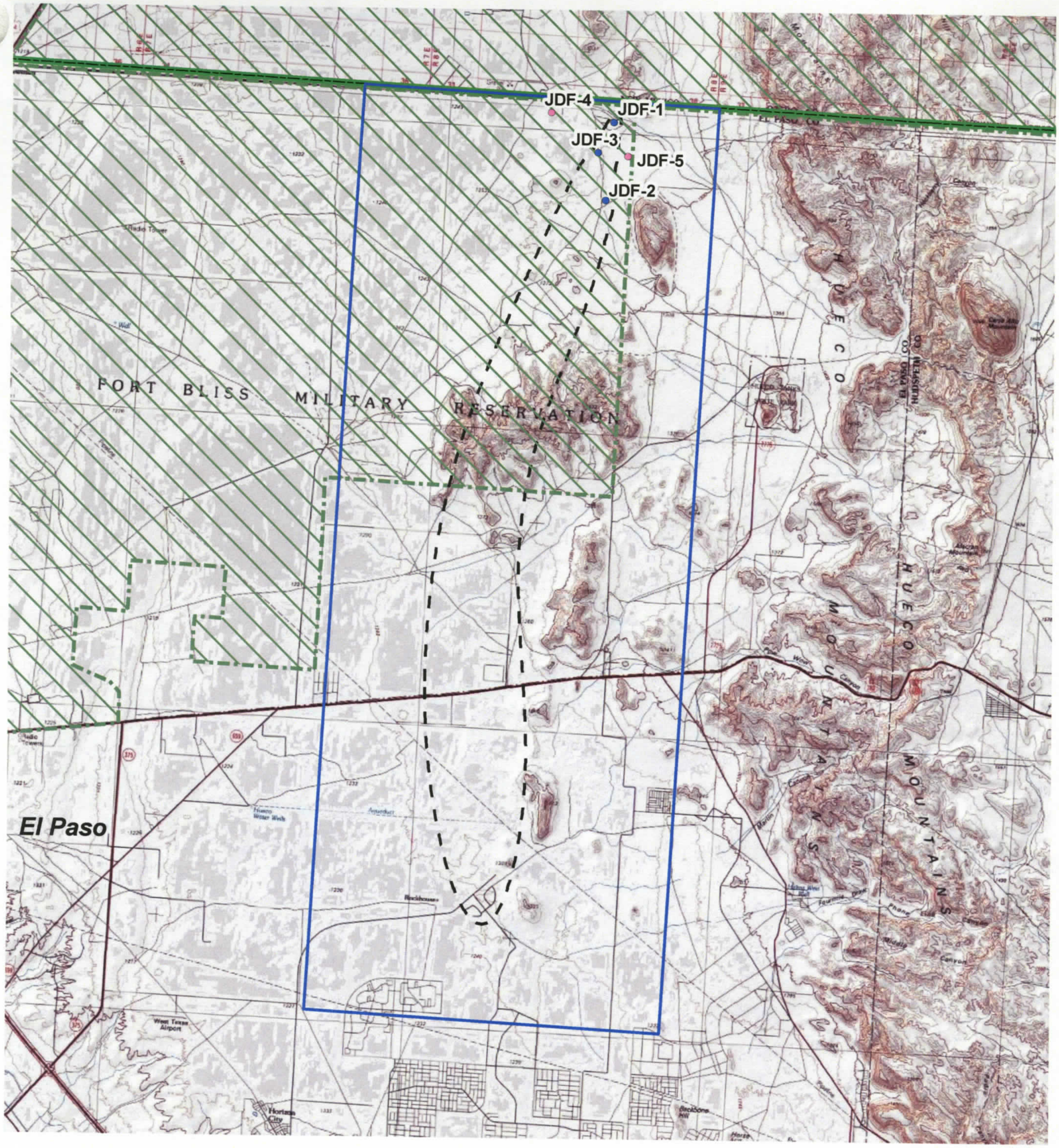
Thanks Bryan!

Brad

<<2 mile buffer exent.pdf>>

Brad L. Cross
Associate
LBG-Guyton Associates
1101 S. Capital of Texas Hwy., Ste. B-220
Austin, Texas 78746

(512) 327-9640 Office
(512) 619-9835 Cell



Explanation

- Class V Injection Wells
- Authorized Injection Wells
- State Boundary
- Fort Bliss
- Concentrate Plume
- Proposed Exempt Area

PROPOSED EXEMPT AREA

FIGURE 2

LBG GUYTON

LBG-GUYTON ASSOCIATES

Proposed Aquifer Exemption
Kay Bailey Hutchison Desalination Plant

El Paso Water Utilities

LBG-Guyton Associates

June 24, 2010

Background

- Plant converts brackish water from the Hueco Bolson to potable water for use by the City of El Paso and Fort Bliss;
- Plant is capable of producing 27.5 mgd of fresh water;
- EPWU received authorization from TCEQ to construct and operate up to five Class V injection wells (TCEQ Authorization No. 5X2700062) completed in the Fusselman Dolomite, Montoya Dolomite, and the El Paso Group (Silurian and Ordovician age);
- Fusselman-Montoya-El Paso Group is considered a USDW because the TDS is < 10,000 mg/L;
- Current Class V injection well authorization prohibits injecting water that does not meet primary drinking water standards, even if the formation water exceeds the primary drinking water standard for that particular parameter;

Background (Cont.)

- Native Fusselman-Montoya-El Paso Group does not meet national and state primary drinking water standards for arsenic, gross alpha, nitrite, and radium. In addition, the formation water is brackish with a TDS of over 8,000 mg/L;
- Most viable option is an "aquifer exemption." The TCEQ and EPA can jointly approve an aquifer exemption by finding that this use (injecting concentrate) in a USDW aquifer may be more important than or otherwise take precedence over, the use of the aquifer as a potential source of water supply for human consumption;
- Areal extent of exemption request is based on a plume that would be generated from the injection of concentrate at a constant rate of 3 MGD for 50 years;
- ACTUAL rate of injection will be based on plant operation that will be governed by the availability of surface water. Plant will also be used to provide for growth, meeting peak demands, and if there is a disruption in other supplies;

Background (Cont.)

- Fusselman-Montoya-El Paso Group is not a source of drinking water for human consumption and there are no water supply wells that penetrate the aquifer;
- Alternative sources (Rio Grande, Hueco Bolson, Mesilla Bolson, Capitan Reef Aquifer, Dell City, Antelope Valley, and Wildhorse Ranch) are available; have a higher quality; and can be produced at a significantly less cost; and,
- Quality of the injected fluids does not significantly affect the existing groundwater quality of the proposed exempt aquifer. Regardless of current or projected concentrate disposal levels, the same membrane treatment would be required prior to using Fusselman-Montoya-El Paso Group as a source of drinking water.

Justification for Exemption

Aquifer exemptions may be granted under EPA 40 CFR §146.4 and TCEQ 30 TAC 331.13 provided the formation meets the following criteria:

1. *40 CFR §146.4 Criteria for Exempted Aquifers*

   An aquifer or a portion thereof which meets the criteria for an 'underground source of drinking water' may be determined under 40 CFR 144.8 to be an 'exempted aquifer' if it meets the following criteria:

   (a) It does not currently serve as a source for drinking water.

2. *40 CFR §146.4(b)(2) It cannot now and will not serve as a source of drinking water because: It is situated at a depth or location which makes recovery of the water for drinking water purposes economically or technologically impractical.*

Exempt Aquifer Description

- Stratigraphy and structural geology determined by DEMs; aerial photos; geologic, gravity, and magnetic data; core data; geothermal exploratory slimholes; four test holes at injection site; and three injection wells;

- Groundwater of measurable quantity is not encountered at the injection site until the proposed exempt aquifer is reached at depths ranging from 2,222 to 2,890 feet;

- Upper confining zone consists of more than 1,700 feet of interbedded shales and limestones. (Top of confining zone is 453 feet BGL with the base at depths ranging from 2,222 to 2,890 feet);

- Lower confining strata beneath lowermost injection interval is Bliss Sandstone (Ordovician); the Bliss is app. 250 feet thick and consists of sandstone, quartzite, and siltstone;

- Proposed exempt aquifer is app. 2,480 feet thick (Fusselman is 590 feet thick, Montoya is 300 feet thick, and El Paso Group is 1,590 feet thick);

Exempt Aquifer Description (Cont.)

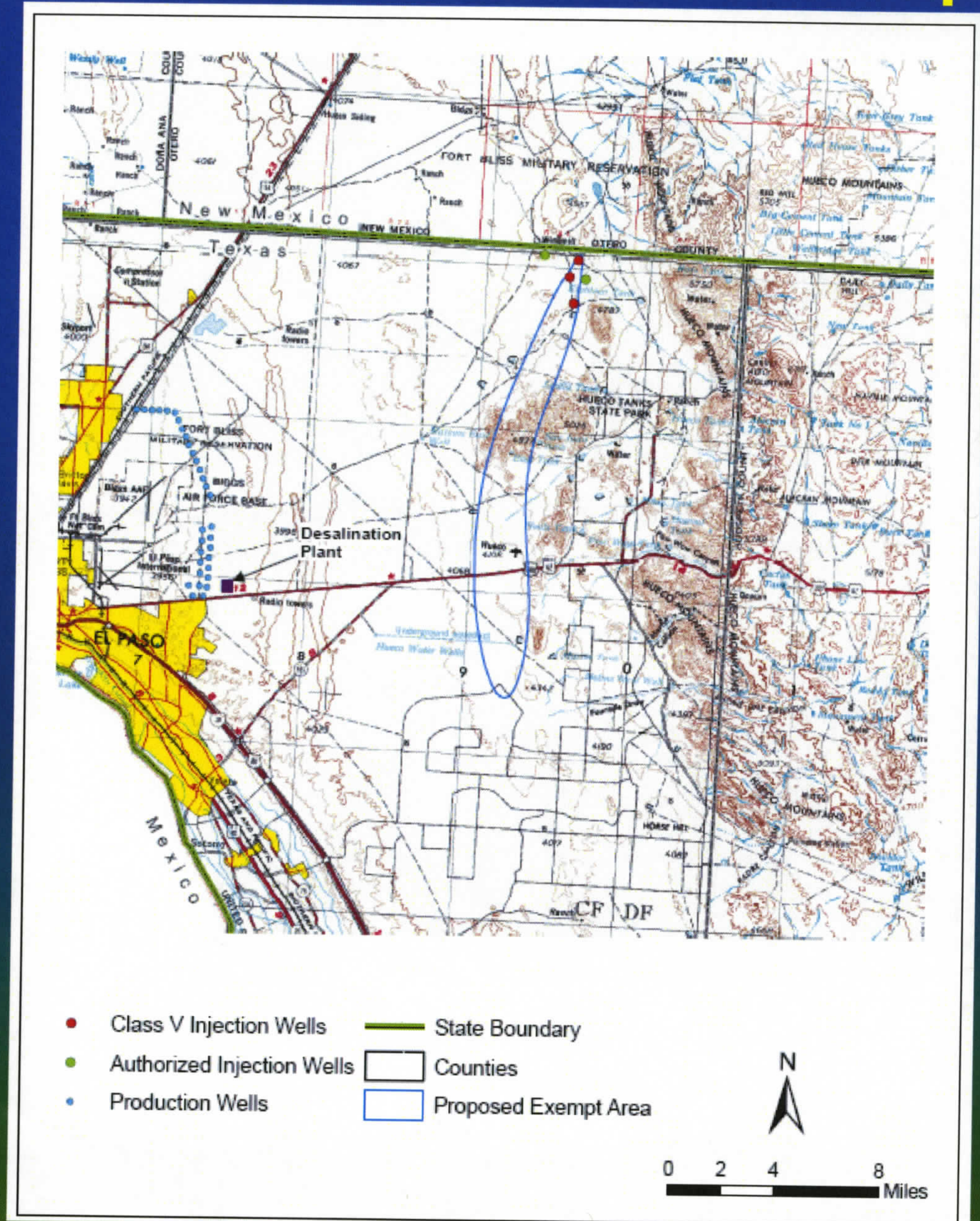
- Static water level data in the injection wells, temperature gradient studies, and published literature support a south to southwesterly groundwater flow direction; Average porosity is 6.3%; Regional gradient is 0.003 foot/foot;

- Proposed exempt aquifer has average TDS of 8,560 ppm and exceeds primary water quality standards for arsenic, gross alpha, nitrite, and radium;

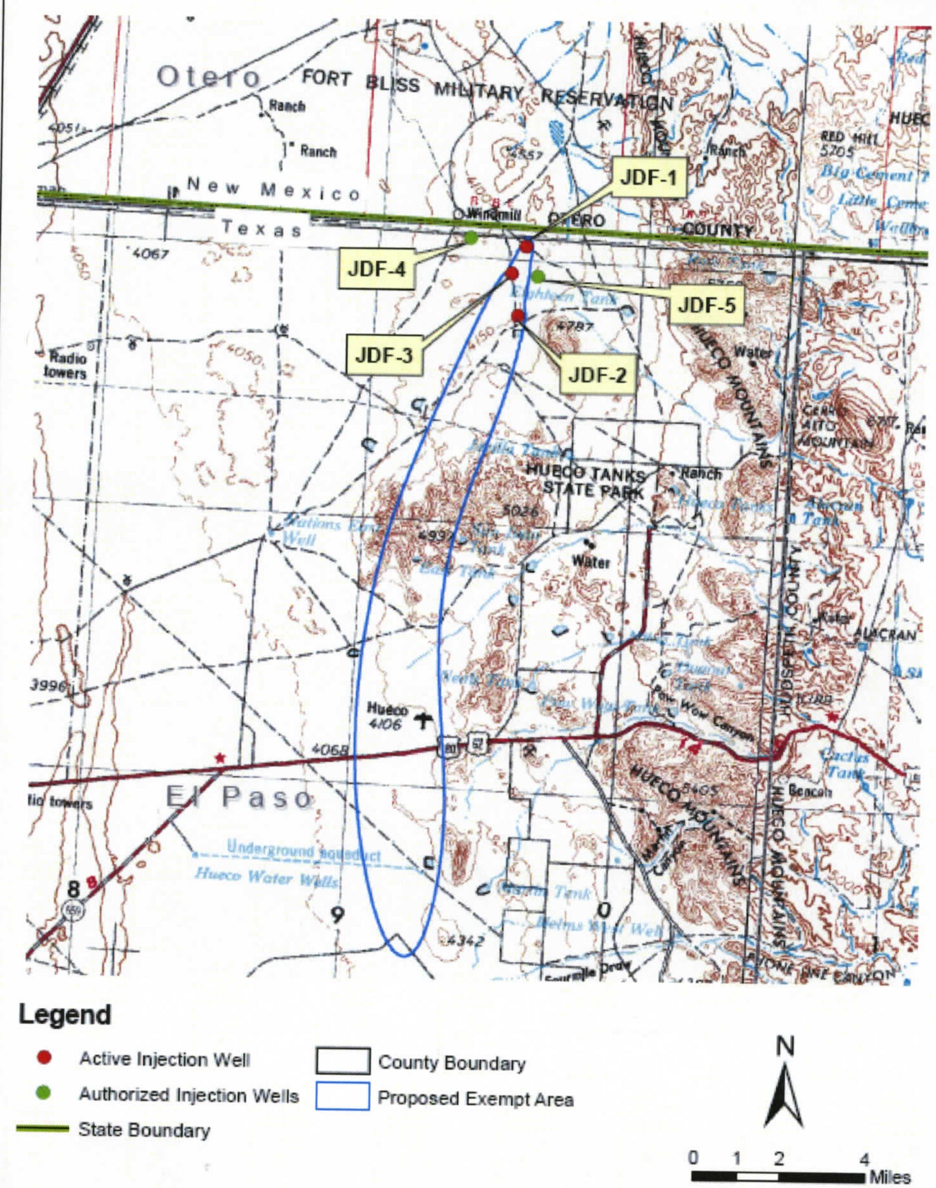
- Delineation based on a constant injection of 3 MGD over a 50-year injection period; *ACTUAL rate of injection will be based on plant operation that will be governed by the availability of surface water. Plant will also be used to provide for growth, meeting peak demands, and if there is a disruption in other supplies;*

- Plume is app. elliptical in shape with a width varying from 0.5 to 2 miles and with a length of 17 miles; the total area included in the proposed exempt area is app. 25.5 sq. miles; Exempt aquifer thickness is 2,480 feet.

General Location Map



Proposed Exempt Area



TCEQ Comment #1

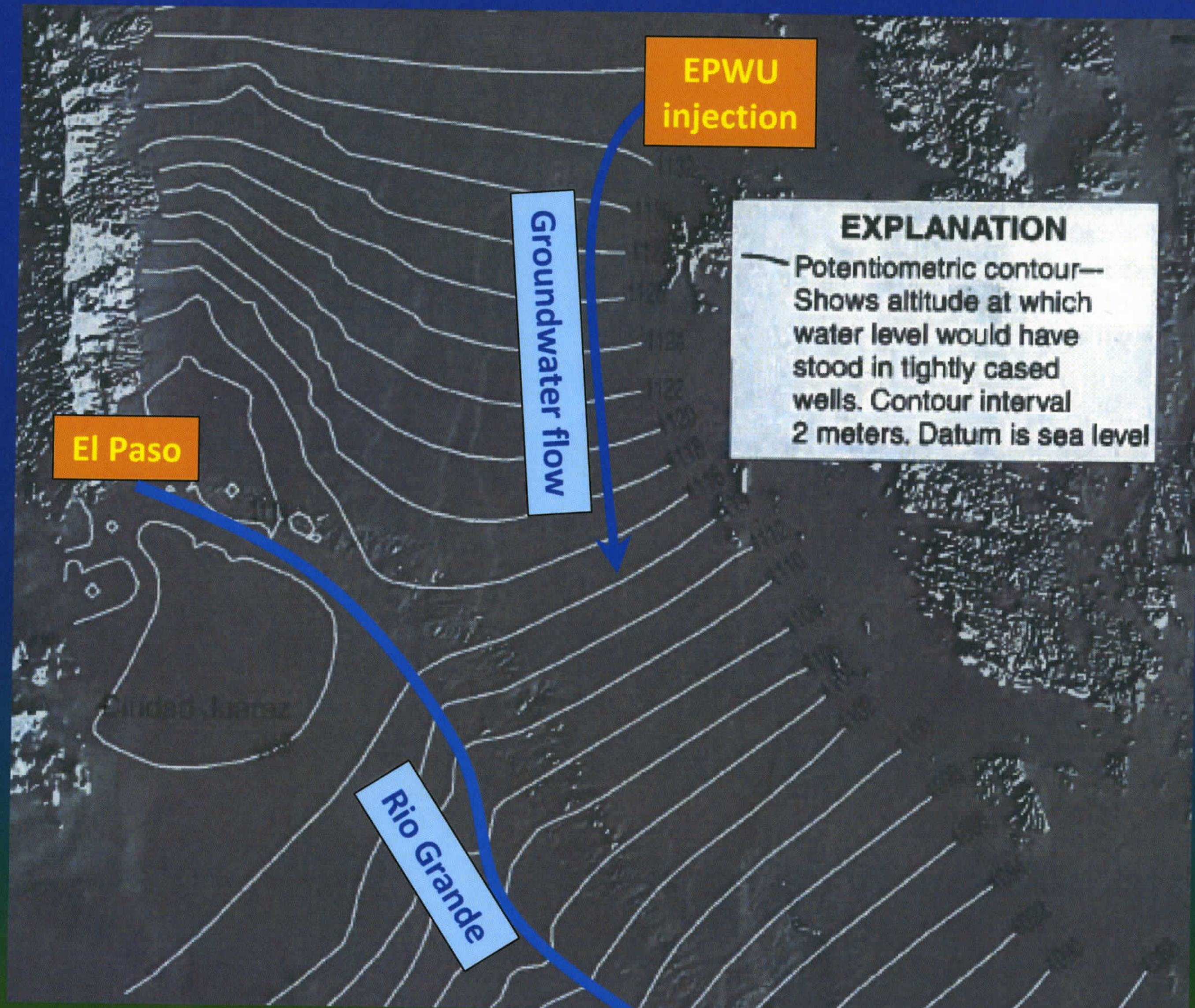
- LBG states that static water level data supports a south to southwesterly flow and groundwater movement to the south can be interpreted by the temperature gradient studies. In the 2008 application, LBG states that static water level data supports a south to southeasterly flow and groundwater movement to the south and southeast can be interpreted by the temperature gradient studies. Please provide the justification for this change in direction.

EPWU Response #1

- The statement was meant to indicate that the flow direction throughout the region is generally to the south, as opposed to the north.

- The following USGS map also indicates that the regional flow direction, based on measured water level data, is also to the south.

USGS Flow Direction and Gradient



USGS Report 02-4108

TCEQ Comment #2

- EPWU states that a groundwater flow direction of south was assumed for groundwater flow in the injection zone. This assumption was based on a similar flow direction for groundwater in sediments of the overlying Hueco-Tularosa Aquifer, as described in an EPA document. The TCEQ is unsure of the validity of this assumption for two reasons. First, the injection zone dips west, as is illustrated on Figure 17. Second, units of the injection zone crop out to the east in the Hueco Mountains (Figure 5), providing an area of recharge for the injection interval. These two features would favor a westward direction for groundwater flow. Please provide additional information to support a southward groundwater flow direction in the units of the injection zone.

EPWU Response #2

- We agree that the injection zone dips to the west, and that geologic structure may play a role in the flow direction, but is not the final determinant of groundwater flow. Groundwater flows from higher "total potential" to lower "total potential". (Freeze and Cherry, Groundwater, page 20)

- While there is Fusselman at the surface to the east of the injection zone, detailed hydrogeologic evaluation indicates that the Fusselman is not present west of that surface outcrop. In addition, scientific publications document that the regional groundwater flow in that area is to the east toward the Diablo Plateau. (Kreitler, Mullican and Nativ, 1990)

Top of Fusselman Structure Map

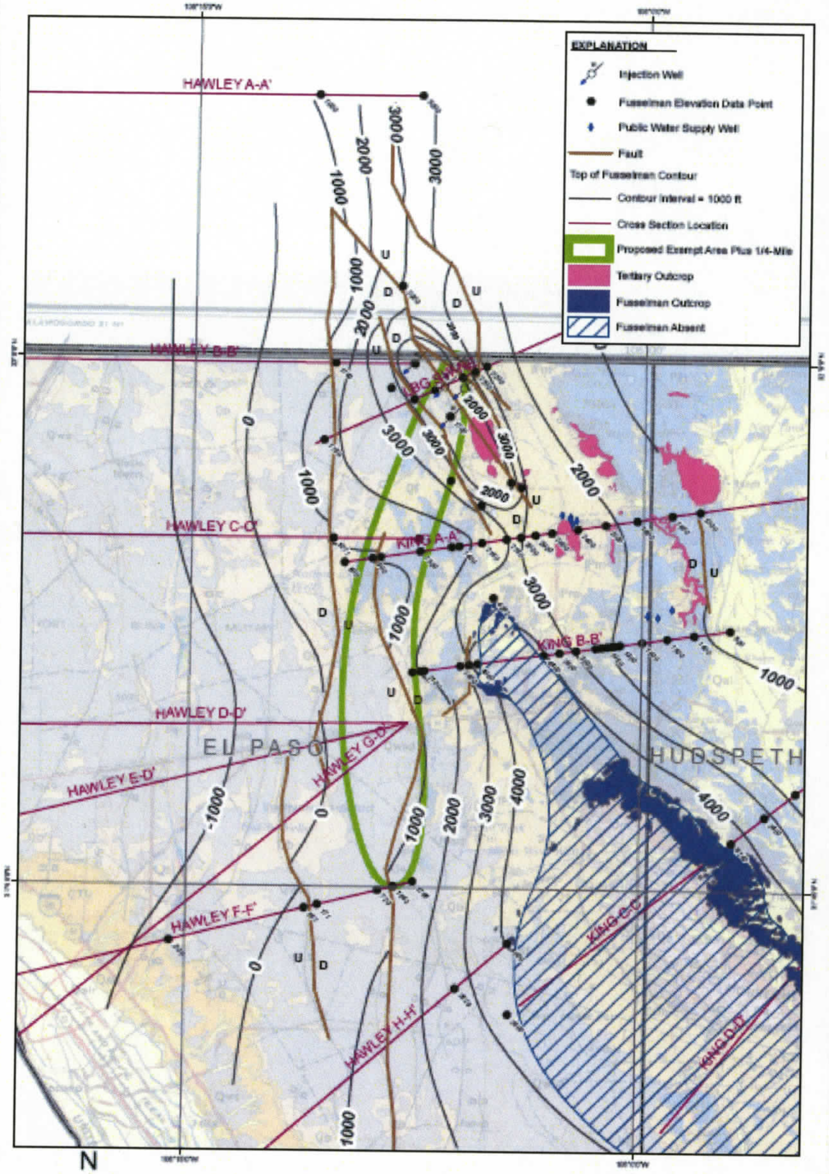


Figure 17 of application

TCEQ Comment #3

- EPWU states that the assumed groundwater gradient in the injection zone was 0.003 ft./ft., based in part on the groundwater gradient in Hueco-Tularosa Aquifer, as reported in an EPA document. The TCEQ is unsure as to how this gradient was determined. It is the TCEQ's understanding that except for water level data from the three injection wells at the site, EPWU has no other groundwater level data for the area that was modeled. Given the size of the area modeled, the TCEQ is not convinced the groundwater gradient in the modeled area is valid. Please provided additional information to support the assumed gradient for the modeled area.

EPWU Response #3

- The hydraulic gradient was determined by measuring head difference over a given distance based on potentiometric maps developed from regional measurements. In this case, the maps were from EPA (1997). These data are indicative of the regional flow in the shallower Hueco-Tularosa system, but can also be used to infer the general flow direction in deeper units such as the injection zone.

- gradient = dh/dl dl=40 miles

- (Freeze and Cherry, Groundwater, page 196) indicates how topography and hydrogeology can impact regional flow systems. Toth (1963) indicates that deeper units in regional flow systems generally have similar but lower hydraulic gradients than the shallower units in the same system.

Regional Systems

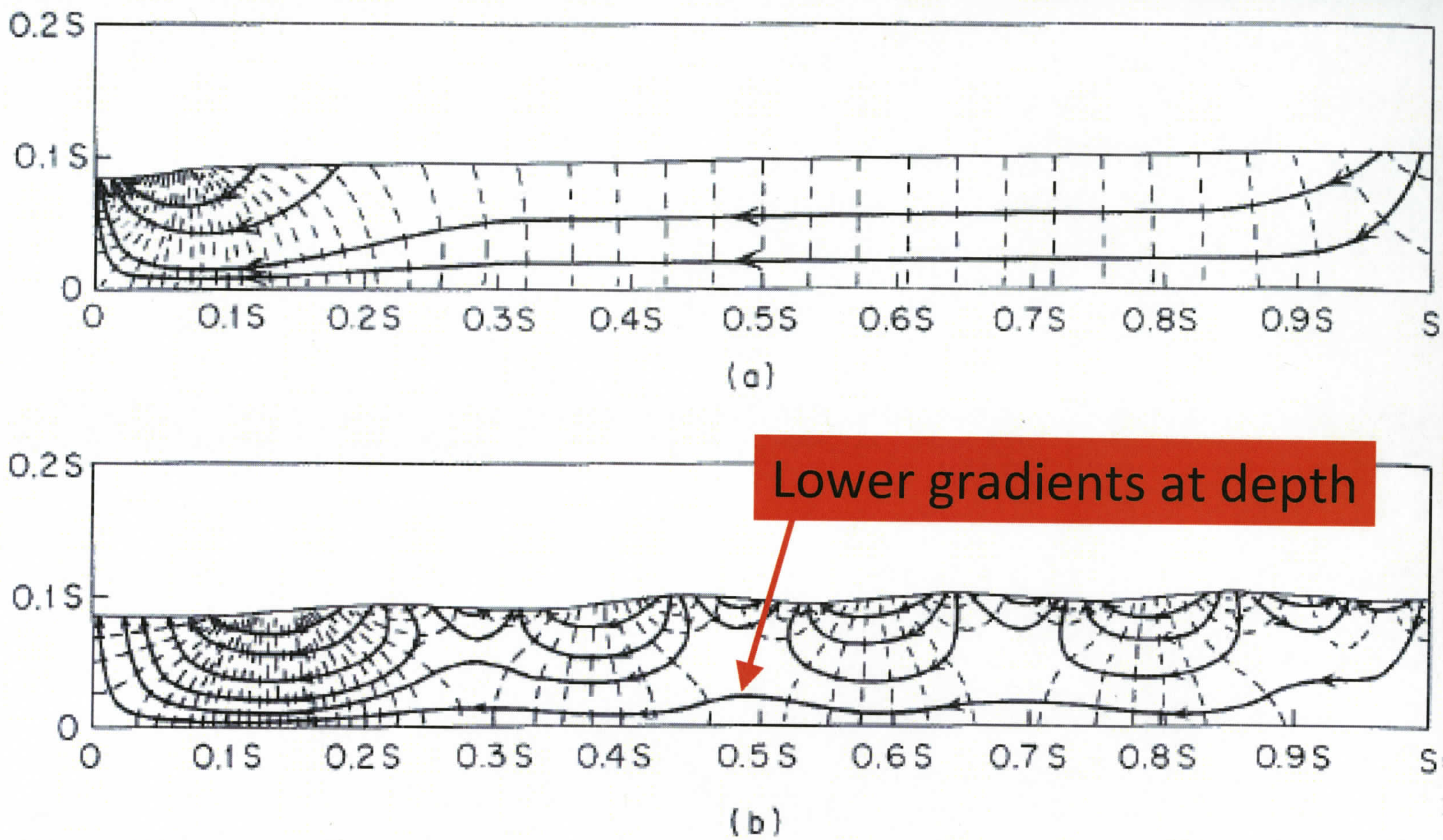


Figure 6.2 Effect of topography on regional groundwater flow patterns (after Freeze and Witherspoon, 1967).

Regional Systems

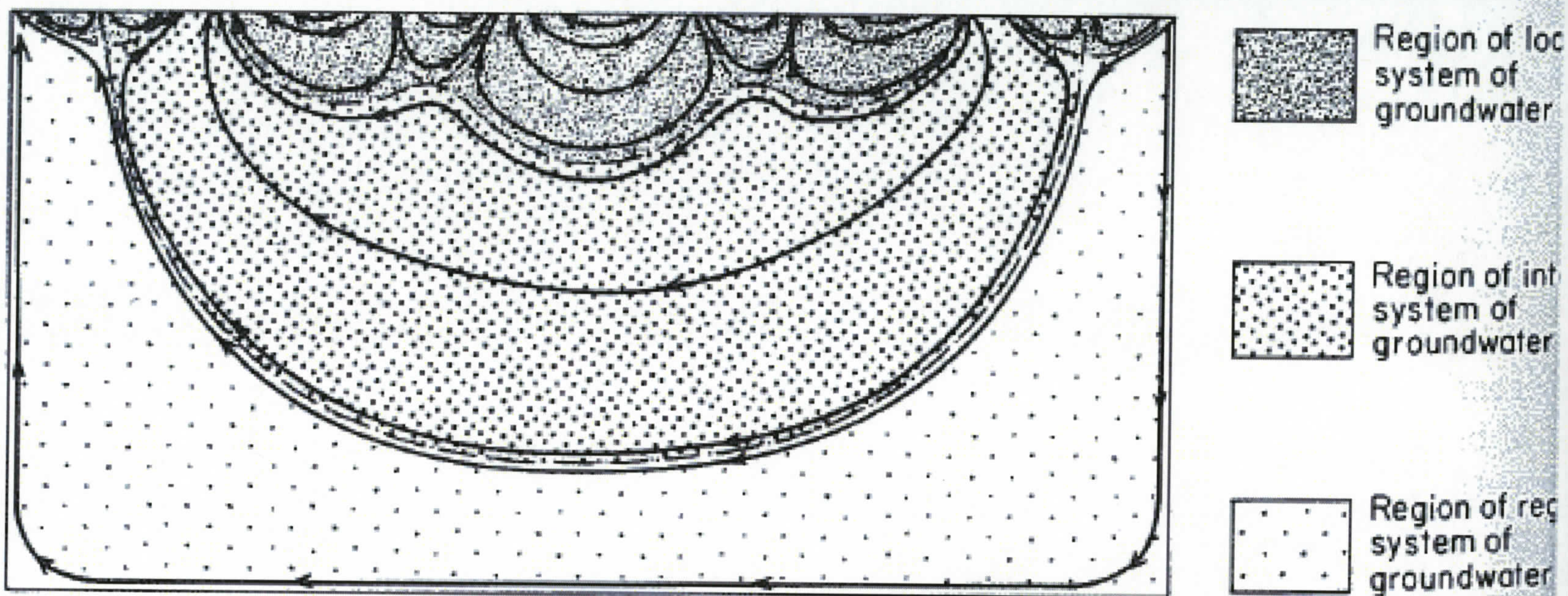
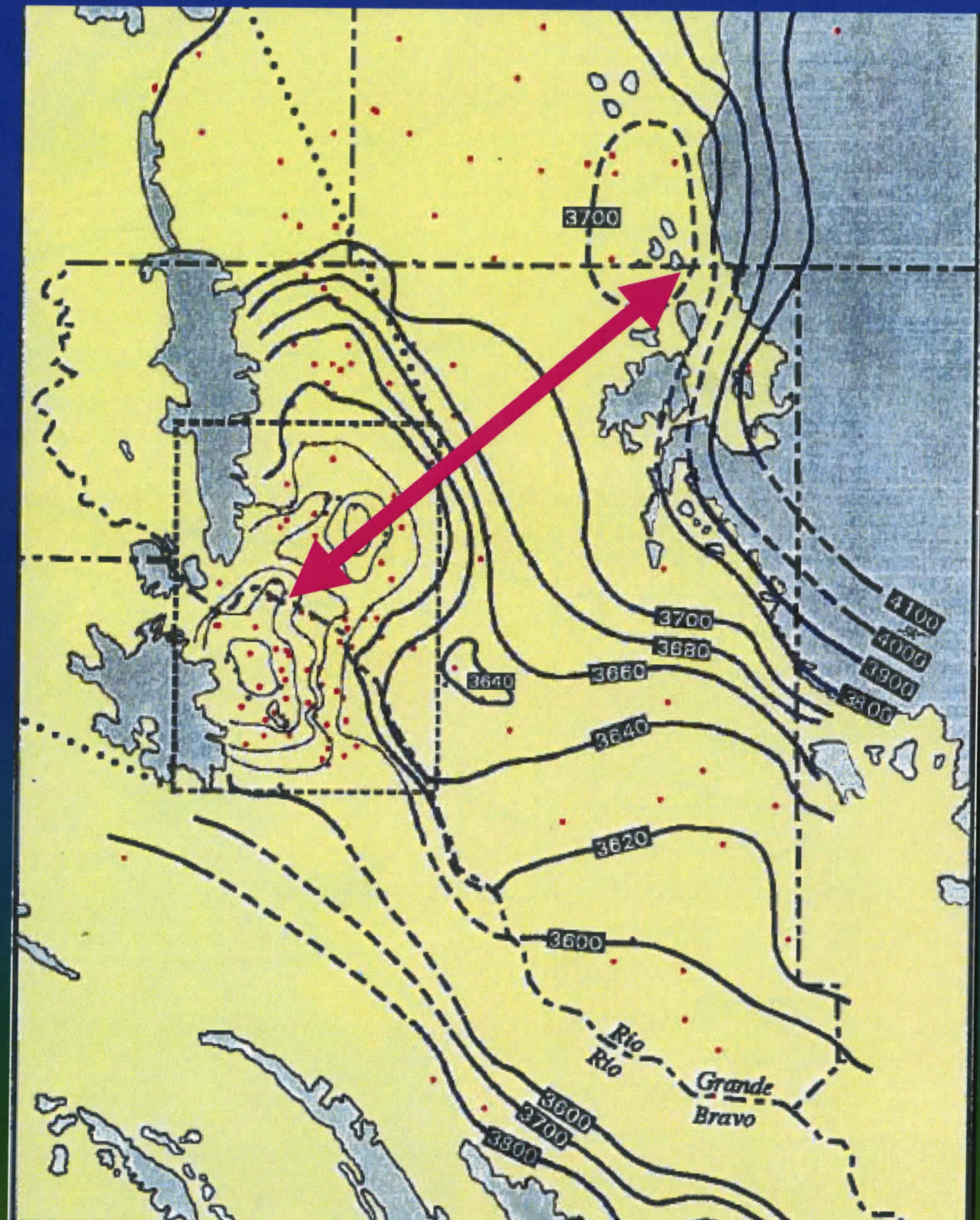


Figure 6.3 Local, intermediate, and regional systems of groundwater flow (after Tóth, 1963).

Regional Systems



Because the model was regional, it was most appropriate to use a regional hydraulic gradient. To demonstrate the inappropriateness of using the local gradient on a regional basis, the following assessment was completed.

Assume the regional hydraulic gradient is equal to 0.009 ft/ft (based on the local water level measurements).

Then, over a 25 mile distance, the head would drop 1188 feet, to a level of about 2480 feet amsl.

There are no documented water levels that low in El Paso County. The closest is about 120 miles downstream in the Rio Grande (near Big Bend).

Conclusion: a regional hydraulic gradient of 0.009 ft/ft is not appropriate to apply on a regional basis in the model. Adopting a regional gradient of 0.003 (as measured in the regional system) is more appropriate.

TCEQ Comment #4

- EPWU states that the boundary conditions set for the model reproduced the observed water levels at the site. Therefore, model calibration appears to be based only on water levels in the three injection wells, which are in a small portion of the total area modeled. No other information was provided with regards to model calibration in other parts of the area modeled. The TCEQ does not agree that water level data from these three relatively closely spaced wells provides sufficient information for adequate calibration of the model, given the size of the area modeled. Please provide additional information for model calibration or please explain why no additional information is necessary for adequate model calibration.

EPWU Response #4

- The model calibration was based both on the local and regional water level measurements and the inferred hydraulic gradients from those measurements (EPA, 1997)

- We agree that the three local water level measurements only represent a small portion of the system, therefore, we also relied on regional measurements to calibrate the model.

TCEQ Comment #5

- LBG states that the area that experiences 1.0 foot or more of head pressure is 17,088 acres whereas previously stated (2008) it was 4,750 acres. Please justify the difference.

EPWU Response #5

- The model result is different due to the changes in hydrogeologic structure and hydraulic gradients in the model. Those two factors result in a slightly larger area of increased pressure as measured by one foot of water level increase in the injection zone.

Conclusions

- Fusselman is not a source of drinking water for human consumption. The aquifer has an average TDS of 8,500 mg/L and is not reasonably expected to supply a public water system. The remoteness and depth (2,200 to 2,890 ft.) renders the aquifer an economically and/or technologically impractical source of drinking water. The Fusselman does not meet primary water quality standards for arsenic, gross alpha, nitrite, and radium.
- Areal extent of exemption request is a worst case scenario and is based on a plume that would be generated from the injection of concentrate at a constant rate of 3 MGD for 50 years.
- ACTUAL rate of injection will be based on plant operation that will be governed by the availability of surface water. Plant will also be used to provide for growth, meeting peak demands, and if there is a disruption in other supplies.
- Alternative sources (Rio Grande, Hueco Bolson, Mesilla Bolson, Capitan Reef Aquifer, Dell City, Antelope Valley, and Wildhorse Ranch) are available, have a higher quality (1,000 to 3,000 mg/L TDS as compared to 8,500 mg/L), and can be produced at a significantly less cost ($163 to $1,400 per acre-foot as compared to $3,000 per acre-foot).

Conclusions (Cont.)

- Quality of the injected fluids does not significantly affect the existing groundwater quality of the proposed exempt aquifer. Regardless of current or projected concentrate disposal levels, the same membrane treatment would be required prior to using Fusselman as a source of drinking water.

- Questions?

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

June 4, 2009

Mr. William R. Hutchison
El Paso Water Utilities
1154 Hawkins Blvd.
El Paso, TX 79961

91 7108 2133 3935 2261 0998
CERTIFIED MAIL

Re: Technical Notice of Deficiency #1
Application for Aquifer Exemption
Class V Authorization 5X2700062; Tracking No. 12421324-1
RN103778882/CN600745392
Joint Desalinization Facility

Dear Mr. Hutchison:

Underground Injection Control (UIC) staff has reviewed the application and technical report for the proposed aquifer exemption prepared by LBG-Guyton Associates dated August 21, 2008. Additional information, clarification and/or revisions are being requested in order for UIC staff to continue the technical evaluation of the permit applications. Please submit the required information within thirty (30) days of the date of this letter. Please note that we do not anticipate granting an extension of time to fulfill this request.

Please submit all requested information in triplicate. The information will be inserted into the appropriate places in the original application and its two copies. Any new or revised text page, table, figure, map or drawing should be clearly marked as a revision, dated and labeled appropriately for insertion into the application. Engineering or geoscience work submitted in response to this letter must be prepared, sealed, signed, and dated by a Texas professional engineer (P.E.) or a Texas professional geoscientist (P.G.), as appropriate.

1. Please provide water quality data for the concentrate that would be injected into the exempted aquifer.

2. Potentiometric Surface

   As illustrated on the geologic map in Figure 5 of the report, Ordovician, Silurian, and Devonian-Mississippian-age rocks crop out about 15 miles southeast of the injection wells, along the southeastern boundary of the Diablo Plateau. According to information on the Van Horn-El Paso Sheet of the Geologic Atlas of Texas Geologic Atlas of Texas, Van Horn-El Paso Sheet, 1967, Bureau of Economic Geology, Univ. Texas-Austin, these rocks represent the Ordovician Bliss Sandstone, El Paso Formation, and Montoya Dolomite, the Silurian Fusselman Dolomite, and the Devonian and Mississippian systems, undivided. On page 17 of the report, rocks of the El Paso, Montoya, and Fusselman formations are identified as those of the proposed exempt aquifer, with rocks of the Bliss Sandstone and those of Devonian-Mississippian-age being parts of the lower and upper confining zones, respectively. Therefore, rocks of the proposed exempt aquifer and the lower and upper confining zones actually crop out southeast of the injection wells. Topographic information on this map indicates the base of the Bliss Sandstone crops out at an elevation of about 4100 feet, with the Fusselman/Devonian-Mississippian contact cropping out at an elevation of about 5100 feet.

Figure 11 of the report is a map of the assumed steady-state potentiometric surface for groundwater in the proposed exempted aquifer area. A comparison of this potentiometric surface to the geology illustrated in Figure 5 indicates that the assumed potentiometric surface for the groundwater in the proposed exempted aquifer area is at an elevation of 3250 to 3450 feet in the area where the Ordovician, Silurian and Devonian-Mississippian rocks crop out. In that the base of these rocks occurs at an elevation of about 4100 feet in this area, the assumed potentiometric surface associated with groundwater in these units is 650 to 850 feet below the base of these units. Clearly, at least in this area, the elevation of the assumed potentiometric surface associated with groundwater in the proposed exempt aquifer is incorrect. Therefore, the results of any groundwater modeling based on this assumed potentiometric surface are questionable.

Additionally, rocks of the Fusselman Formation are at elevations as low as 1200 feet in the area where the injection wells are located (Figure V.B.-3, EPWU's Inventory/Authorization Application for Class V (5X27) Injection Wells, March 8, 2005, volume II). This information suggests structural differentiation between the Hueco Mountains along the western margin of the Diablo Plateau and the McGregor Shelf where the injection wells are located.

Please revise the assumed steady-state potentiometric surface to be consistent with the geology within the area being modeled. Also, please revise the geologic conceptual model to account for the elevation of the proposed aquifer exemption unit in the area of the McGregor Shelf as compared to its elevation in the Hueco Mountains to the west of the McGregor Shelf. TCEQ staff recommends a structure map of the top of the Silurian Fusselman Formation be constructed over this area to aid in determining the structural attitude of the proposed aquifer exemption unit over the modeled area.

3. Hydrologic Gradient

On page 21, LBG-Guyton stated that the hydraulic gradient between wells JDF-1 and JDF-3 is 0.007 ft/ft, and that this gradient was used for groundwater modeling. Based on the well locations provided on Figure 7, this gradient represents a groundwater flow direction of S 45° W. However, the assumed hydraulic gradient used for groundwater modeling is S 40° E (Figure 11). It is unclear why a groundwater flow direction of S 45° W was assumed. The only apparent justification for assuming a southeast direction for groundwater flow is a statement on page 18 of the report that in general, groundwater in the Diablo Plateau region flows to the south and east, discharging in the Dell Valley and Salt Flat areas. However, no documentation was provided in the report to substantiate this statement.

Additionally, it is unclear as to why the magnitude of the hydrologic gradient between wells JDF-1 and JDF-3 (0.007 ft./ft) was used to characterize the hydrologic gradient over the area that was modeled (Figure 11 of the report). This gradient, which was measured between two wells that are about 3300 feet apart, was extrapolated to represent the hydrologic gradient over an area 28 miles by 66 miles, and then only after the direction of the gradient was rotated almost 85 degrees. No justification was given for this extrapolation or rotation.

Furthermore, the 28 mile by 66 mile area to which this gradient was assigned spans parts of the following structural provinces: Hueco Bolson, McGregor Wedge, Hueco Mountains, and the Diablo Plateau. Despite the structural differentiation of each of these entities from one another, the report apparently gave no consideration to the effect this differentiation may have on groundwater flow between these various structural provinces. Groundwater modeling apparently was based on a uniform southeast-directed groundwater flow direction with a uniform gradient.

At the suggestion of Dr. William Hutchinson (04/29/09 meeting between TCEQ and EPWU, Austin, Texas), groundwater elevation data from the three active injection wells were used to solve a three-point problem to determine groundwater flow directions in the immediate area of these three wells. Dr. Hutchinson stated solution of this problem would yield a groundwater flow direction to the southeast. Using the groundwater elevation data supplied by EPWU during this meeting, TCEQ staff performed a three-point problem, which yielded a groundwater flow direction of S 70° W (please see attachment). This flow direction is consistent with groundwater flowing towards the center of the graben called the McGregor Basin by Granillo (2004, A Gravimetric Study of the Structure of the Northeast Portion of the Hueco Bolson, Texas, Employing GIS Technology, p.70).

Please provide justification for the assumed direction and magnitude of the groundwater gradient used in the modeling to determine the extent of the contaminant plume. Again, TCEQ Staff recommend a structure map of the top of the Silurian Fusselman Formation be constructed over this area.

I am available to meet with you and/or your consultant to go over these items. If you desire to schedule a meeting or have questions about any of the items listed in this notice of deficiency, call me at (512) 239-6075. If you will be responding by letter, please include mail code MC 130 in the mailing address.

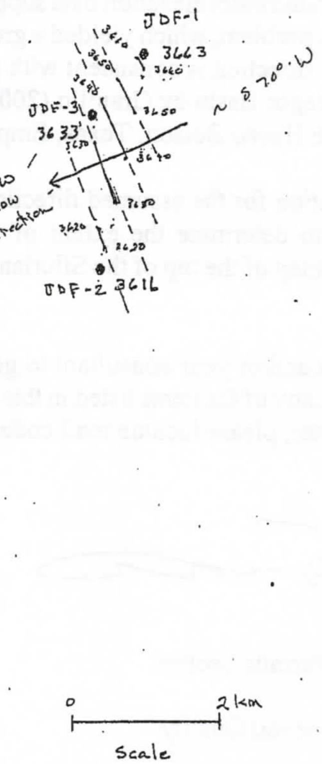
Sincerely,

Bryan Smith

Bryan Smith, Project Manager
Industrial & Hazardous Waste Permits Section
Waste Permits Division
Texas Commission on Environmental Quality

BSS/fp

cc: Mr. Jose Torres, EPA Region 6, 6WQ-S



EPWU

Potentiometric Surface

based on 3-point problem solution

Murry

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

August 13, 2009

Mr. Scott Reinert
El Paso Water Utilities
1154 Hawkins Blvd.
El Paso, TX 79961

Re: Technical Notice of Deficiency #1
Application for Aquifer Exemption
Class V Authorization 5X2700062; Tracking No. 12738790-2
RN103778882/CN600745392
Joint Desalinization Facility

Dear Mr. Reinert:

Underground Injection Control staff has received your letter dated June 30, 2009. Based on the information in the letter, an extension is granted until September 30, 2009. Either the technical notice of deficiency response or an update on the progress of the analytical sample and the modeling results must be submitted at this time.

If you have any questions about this matter, please contact me at (512) 239-6075. If you will be corresponding by mail, please use mail code (MC-130).

Sincerely,

Bryan Smith, Project Manager
Underground Injection Control Permits Team
Radioactive Materials Division

BSS/fp

From: "Brad Cross" <BCross@lbg-guyton.com>
To: bssmith@tceq.state.tx.us; BKNAPE@tceq.state.tx.us
CC: jbeach@lbg-guyton.com
Date: 10/27/2009 9:05 AM
Subject: El Paso Water Utilities Aquifer Exemption
Attachments: Review3.pdf

Good Morning Ben and Bryan,

Hope this finds both of you doing well. As we finalize our refined modeling efforts for El Paso, we wanted to bounce a few ideas off of you and confirm what we will include in the modified application.

Attached is a three page document that includes:

Page 1 - Arsenic concentrations with an injection concentration of 90. This is the 'additional' arsenic that would be added on top of the background. This plume assumes the highest measured gradient (0.007).

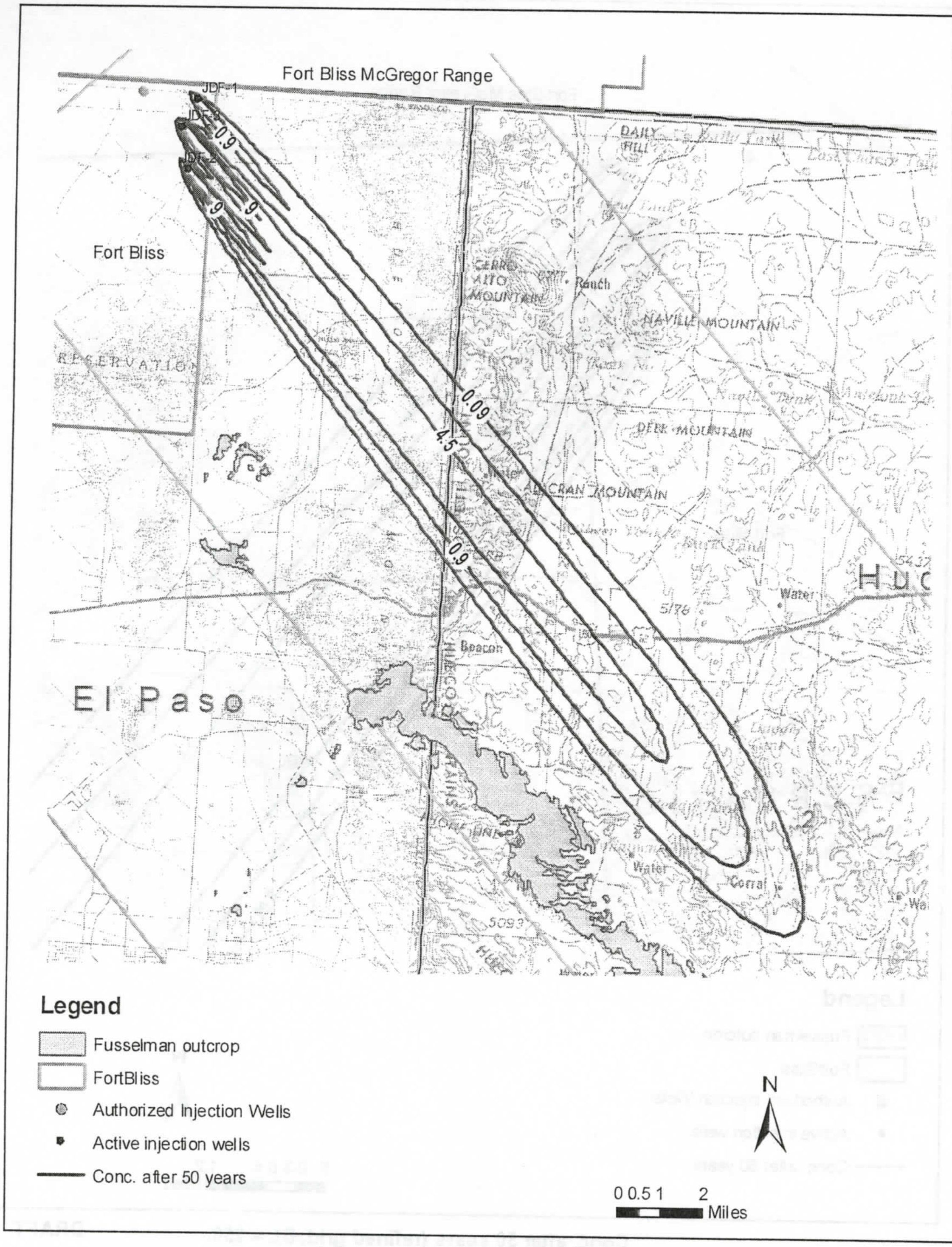
Page 2 - Close up of Page 1.

Page 3 - An older simulation with a lower gradient (0.003).

Is there some time today or early tomorrow that James Beach and I can call you both on a conference call to discuss?

Thanks!

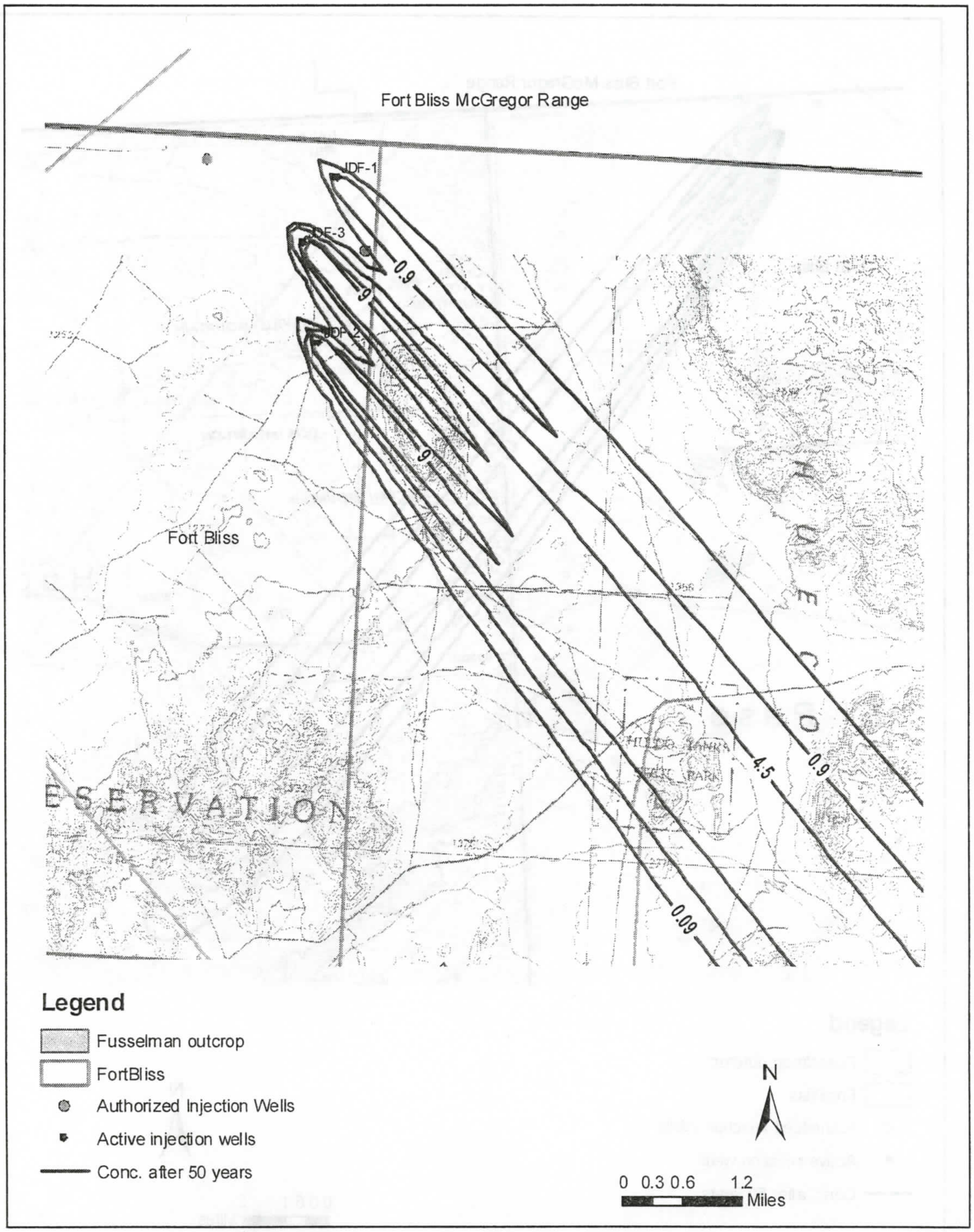
Brad



Conc. after 50 years (refined grid, DL = 250,
p1: 95% injection in JDF2&3 and 5% in JDF1 wells)
(2009.10.16)

DRAFT

LBG-GUYTON ASSOCIATES



DRAFT

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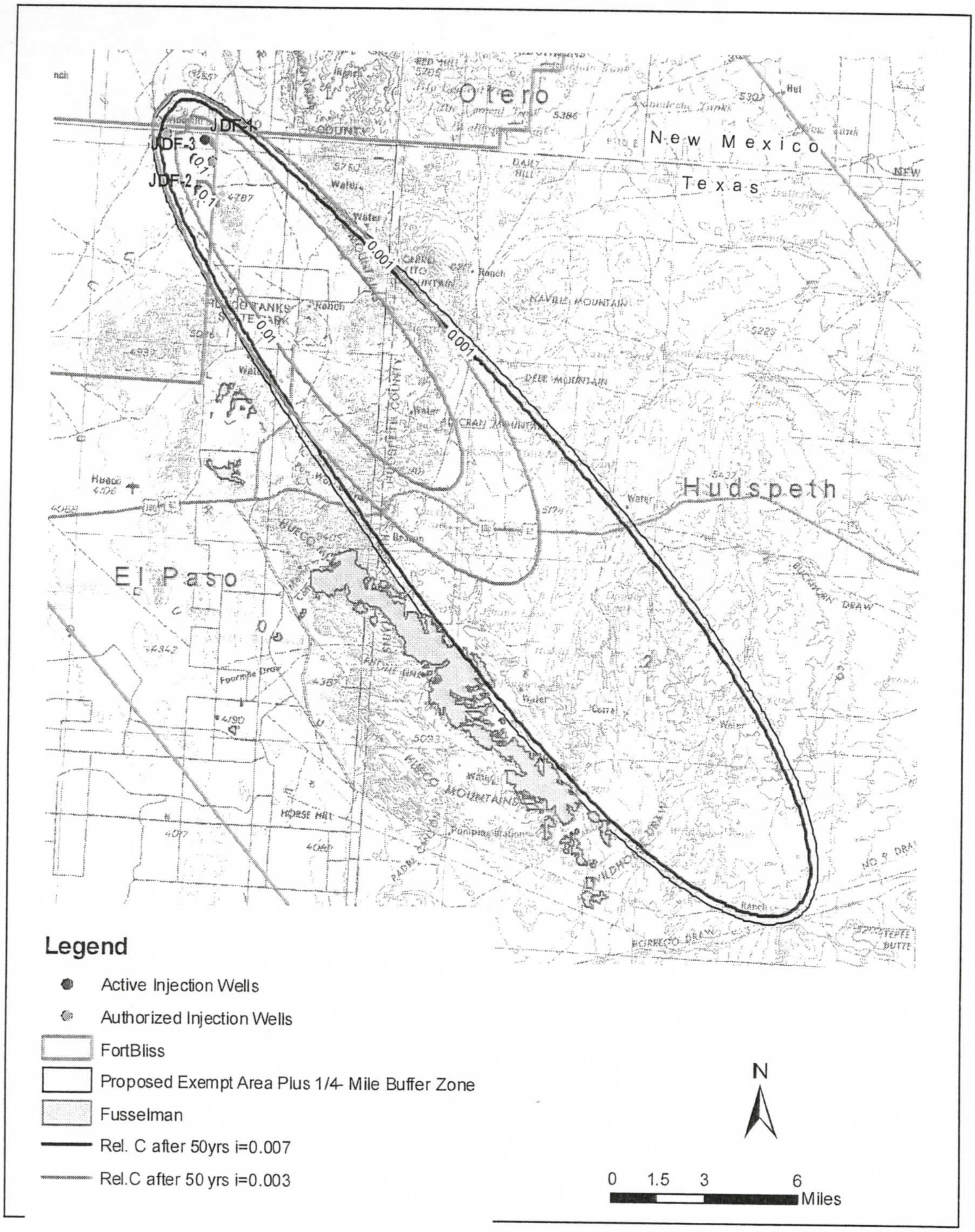
(2009.10.16)

LBG-GUYTON ASSOCIATES



RELATIVE CONCENTRATION OF INJECTATE
AFTER 50 YEARS OF PUMPING

FIGURE 15

LBG-GUYTON ASSOCIATES

LBG-GUYTON ASSOCIATES

PROFESSIONAL GROUNDWATER AND ENVIRONMENTAL ENGINEERING

1101 CAPITAL OF TEXAS HIGHWAY
SUITE B-220
AUSTIN, TX 78746
512-327-9640
FAX: 512-327-5573
www.lbg-guyton.com

April 23, 2010

Mr. Ben Knape, P.G.
Team Leader
Underground Injection Control Permits Team
Radioactive Materials Section
Mail Code 233
P.O. Box 13087
Austin, Texas 78711-3087

Re: Technical Notice of Deficiency No. 1
Application for Aquifer Exemption
Class V Authorization 5X2700062, Tracking No. 12421324-1
CN602957060/RN104809389
Kay Bailey Hutchison Desalination Plant

Dear Mr. Knape:

In response to the Texas Commission on Environmental Quality's (TCEQ) correspondence dated June 4, 2009, enclosed you will find one original and two copies of the revised Aquifer Exemption application.

El Paso Water Utilities (EPWU) requests the designation of an exempted aquifer in conjunction with the use of its Class V injection wells, TCEQ Authorization No. 5X2700062. EPWU requests that the portions of the aquifer described in its April 2010 application be exempt for purposes of the use of Class V injection wells to inject discharged water from a desalination plant used to convert brackish groundwater to potable water.

The enclosed documents should replace the current application package you have on file. While the revised document addresses each of the comments made in your June 4, 2009 correspondence, a short summary of the three primary issues follows:

1) *Provide copy of laboratory analysis of concentrate* – EPWU submitted a copy of the analytical report for an undiluted concentrate sample collected from the Kay Bailey Hutchison Desalination Facility to the TCEQ on September 9, 2009. A copy of the report has also been included in the revised Aquifer Exemption application as Appendix C. Moreover, Table 2 of the revised Aquifer Exemption application provides a 50-year projection of water quality parameters.

2) *Potentiometric Surface* – The potentiometric surface has been reevaluated and we have relied on published EPA documents, static water level measurements in the injection wells, previously published cross-sections, and a geologic structure map for the top of the Fusselman to refine our assessment of the regional potentiometric surface, hydraulic gradients, and potential flow directions. More specifically, in accordance with your June 4, 2009 letter, we have revised the steady-state potentiometric surface and created a structure map of the top of the Fusselman. These revisions are shown in Figures 17 and 19 of the revised Aquifer Exemption application. These changes were used to revise the geologic conceptual model. The data supports a south to southwesterly flow direction which has been incorporated into the revised conceptual model. These issues are described in detail in the hydrogeology and modeling sections of the application.

3) *Hydrogeologic Gradient* – Based upon your June 4, 2009 letter requesting justification of our modeling, we have revised the direction and magnitude of the groundwater gradient used to model the extent of the injectate plume. A brief summary of the analysis supporting the revision follows. Static water level measurements in the three injection wells indicate a hydraulic gradient of 0.008 foot/foot in the direction of 60 degrees west of south. However, the northwest-southeast faulting is expected to have some impact on local water levels and flow directions. EPA documents (Transboundary Aquifers of the El Paso/Ciudad Juarez/Las Cruces Region, 1997) support a southerly regional flow direction in the nearby Hueco-Tularosa aquifer but indicates that flow directions near the injection wells are influenced by complex geology. For the purposes of this evaluation, it was assumed that regional groundwater flow was to the south in the injection zone. While the local hydraulic flow gradient measured at the site (0.008 foot/foot) was considered in developing the flow model, it was determined that this local gradient did not represent regional conditions. This decision was based on two observations. First, the complex nature of the geology and faulting in the area of the wells used to estimate the gradient. Second, the local gradient is significantly higher than the hydraulic gradient in the nearby Hueco-Tularosa aquifer. EPA indicates that the southerly gradient in the Hueco-Tularosa aquifer is about 0.0015 foot/foot. Therefore, it was determined that the regional hydraulic gradient in the Fusselman-Montoya-El Paso Group was 0.003 foot/foot. These issues are described in detail in the hydrogeology and modeling sections of the application.

As previously discussed, the original modeling effort was based on an ultra-conservative modeling approach that produced an extensive proposed exempt area. Based on additional discussions with the TCEQ since the original submittal, LBG-Guyton Associates has refined the numerical model grid to reduce artificial numerical dispersion in the model. This refinement resulted in an improved model that reduced the numerical dispersion that caused the original exempt area to extend into New Mexico. The refined model results in a smaller proposed area of exemption and predicts that the plume does not migrate into the State of New Mexico.

Therefore, we will be requesting a withdrawal of the aquifer exemption request from the New Mexico Environment Department.

Since our original Aquifer Exemption submittal to the TCEQ in August 2008, numerous discussions with agency staff has resulted in the refinement of a proposed exempt area that is key to the successful operation of the Kay Bailey Hutchison Joint Desalination facility. This revised application package clearly resolves several discussed issues, including:

- The areal extent of the aquifer exemption request is based on the plume that would be generated from the injection of concentrate at a constant rate of 3 MGD for 50 years. Actual rate of injection for the concentrate will be based on plant operation that will be governed by the availability of surface water. Specifically, during times of "full" river allocation, groundwater pumpage from the Hueco Bolson and operation of the plant will be minimal. Under "drought" conditions, groundwater from the Hueco Bolson and operation of the plant will be maximized to make up for the shortage of surface water. In addition to drought protection, the plant will be used to provide for growth, meet peak demands, and be used if there is a disruption in other supplies. It is anticipated that the actual amounts of injection will be, on the average, less than the constant rate of 3 MGD for 50 years. As such, the area requested for the aquifer exemption is considered to be more than sufficient.

- The aquifer is not a source of drinking water for human consumption. Its remoteness and depth renders it an economically and/or technologically impractical source of drinking water;

- The aquifer does not represent a future source of drinking water because in addition to having a TDS level above 8,000 mg/L, the aquifer does not meet primary water quality standards for arsenic, gross alpha, nitrite, and radium, making the use of groundwater from the aquifer impractical for human consumption. The undiluted, non-hazardous concentrate does not significantly affect the existing groundwater quality of the proposed exempt aquifer. Extensive research has been conducted at the University of Texas at El Paso's Center for Inland Desalination Systems on the use of membrane technology in the desalination of brackish water and wastewaters. The center has determined that in order for the Fusselman-Montoya-El Paso Group groundwater to be used as a future source of drinking water, it would have to be subjected to rigorous treatment to remove the natural contaminants that are currently present and that the injection of the concentrate would not render the groundwater either less treatable or more costly to treat than it already is;

- Alternative sources of drinking water are available in the area, are of higher quality, and can be produced at a significantly less cost per acre-foot basis;

We sincerely appreciate your consideration of the revised application package and look forward to a favorable response from the Underground Injection Control Permits Team in the near future.

Sincerely,

LBG-GUYTON ASSOCIATES

Brad L. Cross

Brad L. Cross
Associate

From: David Murry
To: Knape, Ben
CC: Jablonski, Susan; Smith, Bryan
Date: 5/26/2010 3:55 PM
Subject: EPWU

Ben,

My original concern regarding the potentiometric surface associated with groundwater in the injection zone was that the extent of the predicted plume included an area where rocks of the injection zone (Silurian Fusselman Fm., Orodvician Montoya Group and El Paso Group)cropped out at the surface, even though the plume was at a depth of over 1,000 feet. EPWU addressed my original concern by changing the location and extent of the predicted plume. Originally, the projected plume extended from the injection site southeast (S40°E) for about 30 miles from the Hueco Mountains across the Diablo Plateau, with a groundwater gradient of 0.007. Now, the predicted plume extends from the injection site to the south-southwest (S20°W for 7 miles, the due south for about 9.5 miles), with a groundwater gradient of 0.003.

EPWU have provided a structural map on the top of the injection interval. This map indicates the injection interval dips about 5° west (Figure 17). Yet, they assume the groundwater in this unit flows to the south. Although they have provided some circumstantial evidence for a south-southwesterly flow of groundwater, they provided no groundwater level data to demonstrate flow in this direction.

To predict the extent of the plume, EPWU assumed gradient of 0.003. Based on the discussion provided on page 22-23 of the revised application, I cannot follow their logic for assuming this gradient in the injection interval. Also, with the exception of the three injection wells, there appears to be no groundwater measurements available in the area of the prediction plume to verify their groundwater modeling results.

Without some groundwater elevation measurements from the injection zone in the Hueco Bolson, there is no way to calibrate their groundwater model. There are no wells in the Hueco Bolson that are completed in the injection zone. Also, because of the complex geology along the western boundary of the Diablo Plateau, it would require numerous wells completed in the injection zone to adequately characterize the groundwater flow regime for the injection interval in this area, at least to the extent needed for determination of an injection plume.

Given, the quality of the water in the injection zone, one option would be to just exempt a large area, say from the Hudspeth/El Paso County line eastward some distance and from the New Mexico/Texas State line southward some distance.

A second option would be to reconsider the Class V authorization requirement that the concentrate meet Primary Drinking Water Standards for arsenic and gross alpha. As stated by EPWU (page 2), groundwater in the injection zone does not meet PDWS for these two constituents. To my way of thinking, we could consider if injecting the concentrate will change the class of use of the groundwater in the injection zone.

Although Texas has standards for drinking water, the state has none for other uses, such as livestock, irrigation, or industrial use. However, there are standards for these classes of use in the Wyoming rules and in published literature, specifically in Water Quality Criteria, 1972, National Academy of Sciences, Academy of Engineers, EPA-R3-73-033.
Below are the standards for arsenic (mg/l) and gross alpha (pCi/l):

	Wyoming		NAS	
	Irrigation	Livestock	Irrigation	Livestock
Arsenic	0.1	0.2	0.01; 5.0*	0.2
Gross α	15	15	15	15

*First value is for continuous use; second is for use up to 20 years on fine-textured soils with neutral to alkaline pH.

With respect to arsenic, both the groundwater in the injection zone and the concentrate are suitable for irrigation and livestock under the Wyoming rules. Based on NAS standards, both are suitable for livestock, and may be suitable for irrigation, depending on the type of soil to which they are applied. Gross α standards for irrigation and livestock are the same as the primary drinking water standard, both for Wyoming and NAS.

In Table 2 of the revised application, arsenic concentration in the injection zone groundwater, after 50 years of injection, is projected to meet the Wyoming standards for irrigation and livestock, the NAS standards for irrigation, and possibly the NAS standard for irrigation. The groundwater in the injection zone after 50 years of injection still will not meet any standards for gross α.

Neither the Wyoming rules nor the NAS has standards for industrial use with regards to arsenic and gross α.

Based on currently available standards, the groundwater in the injection zone, the concentrate, and the groundwater after 50 years of injection all fall within the same use classes; injection of the concentrate is not expected to change the class of use of the groundwater with respect to arsenic and gross α.

Allowing injection of the concentrate without first diluting it will not change the suitability of the groundwater in the injection zone with respect to arsenic and gross α. We need to discuss this further, as there may be factors that I am not aware of, but presently I see no reason not to consider a revision of the authorization to allow injection without dilution.

David

Chronology of El Paso Class V Well Authorization and Aquifer Exemption Applications

March 8, 2005 – EL Paso submitted Class V application for injection of desalination concentrate.

April 29, 2005 – TCEQ UIC staff sent E-mail requesting additional information on the application.

June 15, 2005 – UIC staff sent letter requesting updated tables for the Class V application.

June 20, 2005 – El Paso submitted response to UIC staff's June 15, 2005 request.

July 13, 2005 –UIC staff authorized Class V injection wells for El Paso Desalination Plant.

June 7, 2006 – El Paso requested amendment of requirement for inspection of casing and received approval.

June 13, 2007 –El Paso requested approval to repair annulus integrity using 300 PSI polymer product.

June 14, 2007 – El Paso requested amendment of Class V authorization:

> Replacing requirement for injectate to meet primary drinking water standards (PDWS) with new requirement to meet TDS not to exceed 10,000 mg/l;
>
> Allowing temporary exceedance of the 10,000 mg/l limit for testing purposes;
>
> Changing the MIT frequency to every 5 years; and
>
> Increasing injection pressure and rate.

July 18, 2007 – El Paso submitted well completion reports.

August 7, 2007 – El Paso and UIC staff met to discuss the June 14, 2007 amendment request.

August 23, 2007 – El Paso revised June 14, 2007 amendment request by dropping the temporary exceedance request with respect to injectate quality.

August 27, 2007 – UIC staff sent letter approving the continued testing and operation of wells 1 and 3 while completion reports are being reviewed.

October 8, 2007 – UIC staff sent letter approving the use of 300 PSI polymer product to seal the casing-tubing annulus of second well.

October 17, 2007 – UIC staff responded to amendment request of June 14, 2007 and August 23, 2007: request to rescind PDWS requirement for injectate quality was denied; changes in MIT frequency were approved; changes in injection rate and pressure were denied.

8/21/08 – El Paso submitted request for aquifer exemption: TCEQ staff indicated that El Paso's noncompliance with the Class V well authorization requiring quarterly operating reports could impact processing of the exemption request.

January 26, 2009 – El Paso submitted reports.

April 6, 2009 – New Mexico sent letter denying the Aquifer Exemption request.

June 4, 2009 – UIC staff sent NOD on exemption request.

June 30, 2009 – El Paso submits partial NOD response on exemption request.

July 1, 2009 – UIC staff met w/ El Paso and consultants to discuss NOD response: TCEQ staff expressed serious concerns about the submitted information not providing justification for El Paso's interpretations of geology and selection of inputs on hydrologic gradient and direction of flow to produce a valid plume model for sizing the aquifer exemption.

September 11, 2009 – El Paso requested amendment of Class V authorization conditions on injectate quality, and limits on injection pressure and rate.

November 4, 2009 - By conference call, El Paso's consultants sought guidance from UIC staff on constituent concentrations and ground water gradients for use in revising the model:

> Staff indicated that the burden lies on the applicant to design and justify its own demonstration that the proposed exempted area criteria (size, depth, and concentrations defining the plume boundary) meet requirements;
>
> Without a convincing demonstration with sufficient geologic data to justify a modeled plume extent of approximately 20 miles down-gradient, the executive director will not be able to reach a preliminary decision that the proposal meets rule requirements, and will not be able to justify the proposed exemption to EPA for federal approval;
>
> El Paso's consultants indicated that they would adjust the modeling demonstration and resubmit it for UIC's review.

April 23, 2010, El Paso submitted a new version of the aquifer exemption application to address the above noted concerns. This version of the application is under technical review by UIC staff.

Re: El Paso Aquifer Exemption

Chronology of El Paso Aquifer Exemption Application

March 8, 2005 – Class V Application for injection of desalination concentrate from the desalination plant.

April 29, 2005 – Sent E-mail requesting additional information on the application.

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June 14, 2007 – Amendment requests to Class V authorization. Replace primary drinking water standards with TDS of 10,000 mg/l. Tempoary exceedance of the 10,000 mg/l limt for testing purposes. Change in the MIT requirements. Change in the injection pressure and rates.

August 23, 2007 – Revised amendment request to the June 14, 2007 letter. Dropped the temporary exceedance request.

August 27, 2007 – Letter approving the continued testing of the system while completion reports are being reviewed.

October 8, 2007 – Letter approving the use of 300 PSI to fix the annulus space.

October 17, 2007 – Response to amendment request of August 23, 2007. DWS denied. MIT changes approved. Rate change denied.

8/21/08 - received request for aquifer exemption; technical review delayed by El Paso's noncompliance in sending quarterly operating reports as required by Class V well authorization

January 26, 2009 – Reports submitted by El Paso.

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November 4, 2009 - by conference call, El Paso's consultants sought guidance from TCEQ staff on constituent concentrations and ground water gradients for use in revising the model. UIC staff responded that the burden lies on the applicant to design and justify its own demonstration that the proposed exempted area criteria (size, depth, and concentrations defining the plume boundary) meet requirements. Without a convincing demonstration with sufficient geologic data to justify a modeled plume extent of approximately 20 miles down-gradient, the executive director will not be able to reach a preliminary decision that the proposal meets rule requirements, and will not be able to justify the proposed exemption to EPA for federal approval. El Paso's consultants indicated that they would adjust the modeling demonstration and resubmit it for UIC's review.

April 23, 2010, El Paso submitted a new version of the aquifer exemption application to address the above noted concerns. This version of the application is under technical review.

Re: El Paso Aquifer Exemption

Chronology of El Paso Aquifer Exemption Application

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April 23, 2010, El Paso submitted a new version of the aquifer exemption application to address the above noted concerns. This version of the application is under technical review.

Bryan Smith - El Paso Aquifer Exemption

From: Bryan Smith
To: Cross, Brad
Date: 6/21/2010 4:08 PM
Subject: El Paso Aquifer Exemption
CC: Ben Knape; Murry, David
Attachments: Bryan Smith.vcf

Brad,

We have reviewed the new application for aquifer exemption for El Paso. UIC staff has some concerns based on this review.

Exempt Aquifer Description

Under the heading titled Groundwater Flow, (pg 19) LBG states that static water level data supports a south to southwesterly flow and groundwater movement to the south can be interpreted by the temperature gradient studies. In the 2008 application, LBG states that static water level data supports a south to southeasterly flow and groundwater movement to the south and southeast can be interpreted by the temperature gradient studies. Please provide the justification for this change in direction.

Reservoir Modeling

Under the heading titled Conceptual Model, (pgs 21-23), EPWU states that a groundwater flow direction of south was assumed for groundwater flow in the injection zone. This assumption was based on a similar flow direction for groundwater in sediments of the overlying Hueco-Tularosa Aquifer, as described in an EPA document. The TCEQ is unsure of the validity of this assumption for two reasons. First, the injection zone dips west, as is illustrated on Figure 17. Second, units of the injection zone crop out to the east in the Hueco Mountains (Figure 5), providing an area of recharge for the injection interval. These two features would favor a westward direction for groundwater flow. Please provide additional information to support a southward groundwater flow direction in the units of the injection zone.

Under the heading titled Conceptual Model, (pgs 21-23), EPWU states that the assumed groundwater gradient in the injection zone was 0.003 ft./ft., based in part on the groundwater gradient in Hueco-Tularosa Aqufier, as reported in an EPA document. The TCEQ is unsure as to how this gradient was determined. It is the TCEQ's understanding that except for water level data from the three injection wells at the site, EPWU has no other groundwater level data for the area that was modeled. Given the size of the area modeled, the TCEQ is not convinced the groundwater gradient in the modeled area is valid. Please provided additional information to support the assumed gradient for the modeled area.

Under the heading titled Model Development and Calibration (pgs 24-25), EPWU states that the boundary conditions set for the model reproduced the observed water levels at the site. Therefore, model calibration appears to be based only on water levels in the three injection wells, which are in a small portion of the total area modeled. No other information was provided with regards to model calibration in other parts of the area modeled. The TCEQ does not agree that water level data from these three relatively closely spaced wells provides sufficient information for adequate calibration of the model, given the size of the area modeled. Please provide additional information for model calibration or please explain why no additional information is necessary for adequate model calibration.

Under the heading titled Assessment of Vertical Plume Movement (pgs 27-29), LBG states that the area that experiences 1.0 foot or more of head pressure is 17,088 acres whereas previously stated (2008) it was 4,750 acres. Please justify the difference.

Bryan S. Smith
bssmith@tceq.state.tx.us

Bryan S. Smith
bssmith@tceq.state.tx.us

GEOTHERMAL RESOURCE POTENTIAL OF McGREGOR RANGE, NEW MEXICO

by

James C. Witcher
Southwest Technology Development Institute
New Mexico State University
Las Cruces, New Mexico

Glenn
7/10/01

NMSU/SWTDI REPORT GEO-97-5

TABLE OF CONTENTS

FIGURES

geothermometry (Henry and Gluck, 1981; Hoffer, 1978 and 1979; Taylor and others, 1980; and Taylor, 1981). Regional gravity and aeromagnetic maps provide supplemental subsurface structural information. These surveys have provided a framework to select the sites for geothermal test drilling. Four slim-hole continuous-wireline core holes have provided deep subsurface information on the nature of the McGregor geothermal system (Witcher and others, 1997; and Finger and Jacobson, 1997).

STRUCTURE AND SUBSURFACE GEOLOGY

Structural Setting

The McGregor geothermal system is located along the eastern hinge or flexural margin of a major Rio Grande rift half-graben complex, the Tularosa-Hueco Basin (Woodward and others, 1978). The Tularosa-Hueco half graben is rotated downward to the west along an east-facing boundary fault margin, the East Franklin Mountain fault system (Collins and Raney, 1994; Seager, 1980, and Machette, 1987) (Figure 2). Seismic and gravity survey interpretations suggest that nearly 2,740 m (9,000 ft) of basin-fill sediments fill the half graben at maximum structural relief, a few miles east of the surface expression of the East Franklin Mountains boundary fault.

The East Franklin Mountains fault is a segment of a much larger fault system which extends from El Paso northward into New Mexico along the Franklin, Organ, and San Andres Mountains for about 192 km (120 mi) (Machette, 1987). This extended fault system shows significant Pleistocene to Recent movement and represents one of the larger Quaternary fault systems in the interior of the United States (Machette, 1987; Collins and Raney, 1994; Gile, 1987; and Gile, 1994). Seager (1980) discussed a 25 km wide zone of related intra-graben faults which cut basin-fill sediments and Quaternary surfaces with between 3 and 28 m of offset. These faults exhibit anastomizing patterns and are generally between 12 and 25 km in length with synthetic and antithetic relationships to the East Franklin Mountains fault.

An enchelon series of northwest-trending intra-basin cross faults and basin floor flexures are mapped by Seager (1980) and Seager and others (1987) to extend across the half graben from the southern Organ Mountains southeastward to the area of the McGregor Range Camp. The southeastern terminous of the cross faults approximates the location the northern end of the McGregor geothermal system (Figures 1 and 3). In general, the cross fault system is antithetic to the East Franklin Mountains boundary fault system.

An additional Pleistocene intrabasin fault was recently identified just east of Davis Dome (Witcher, 1997) (Figure 3). The La Mesa surface caliche (stage IV to V) (Monger, 1993) is displaced 5 to 15 meters along this fault zone (Witcher, 1997). This fault is synthetic to the East Franklin Mountains boundary fault and appears to mark the east margin of a minor intrabasin horst within the half-graben flexural margin. This minor intrabasin horst appears to host the McGregor geothermal system upflow and outflow plume (Witcher, 1997). The horst or uplift is partially buried by basin fill with bedrock outcrops at Davis Dome and in the vicinity of the Meyer Small Arms Range near the New Mexico-Texas line.

Within the rift nomenclature of Morley (1990), the McGregor geothermal area represents a divergent-conjugate accommodation zone. The intrabasin cross-fault system, extending northwestward from this region, may represent yet another rift transfer zone. From a regional perspective, the cross-fault system may mark the beginning of the transition to the Trans-Pecos or Big Bend segment of the Rio Grande rift. This segment of the rift in western Texas is characterized by en echelon grabens that step to the left along the so-called Texas Lineament (Dickerson and Muehlberger, 1994).

Subsurface Geology

Information about the subsurface geology for the McGregor geothermal system is derived from four deep slim-hole continuous-wireline core holes (Witcher and others, 1997) (Figure 3). Depth-to-bedrock is highly variable over

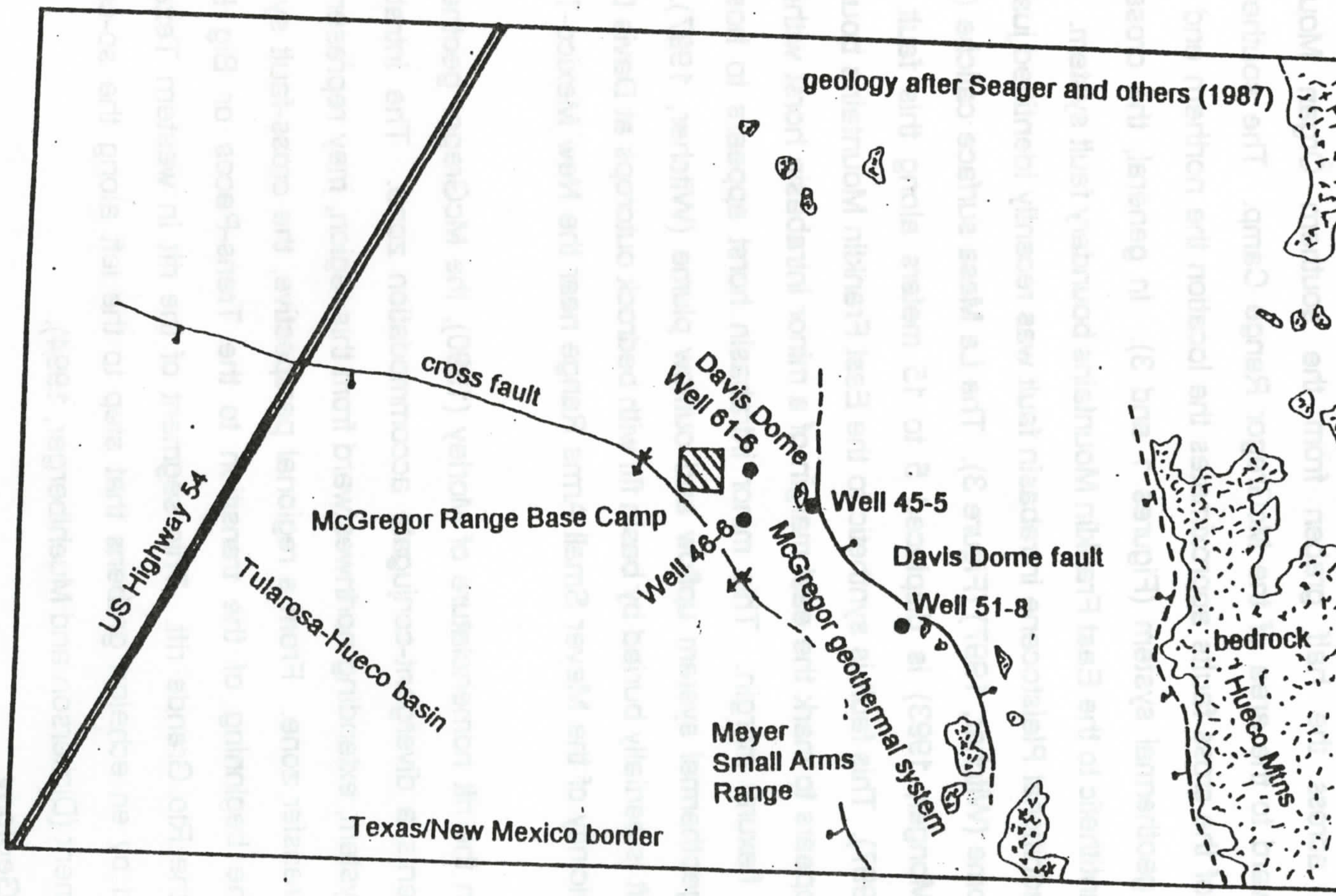

Figure 3 Generalized map of the McGregor Range Camp area.

the partially buried horst block . Basin fill thickness ranges from 710 feet in well 46-6 to about 30 feet in well 45-5. Basin fill consists of variably indurated pebbly sand, sand, silt and clay. Highly-indurated caliche (La Mesa surface) about 10 feet maximum thickness caps the basin-fill sequence. Wind blown sand forms a thin surficial veener over the caliche cap.

Paleozoic limestone and dolomite and Tertiary felsite intrusives are the major bedrock units cored. Paleozoic rocks units include: 1) Ordovician and Silurian dolomite, cherty dolomite, and chert of the Montoya Group and Fusselman Formations; 2) Devonian (?) and Mississippian black argillaceous limestone and calcareous shale and dark fossiliferous and sometimes cherty limestones of the Las Cruces, Rancheria, and Helms Formations; and 3) Pennsylvanian gray to dark gray cherty, fossiliferous limestones of the Magdalena Group. Tertiary felsite intrusives show concordant contacts and are generally interpreted as sills. Well 45-5 cored a small laccolith. Limestone above the felsite intrusion shows moderate dips; however, the intrusion is floored by flat lying limestone. Formation tops and thickness drilled in each well are shown in the Appendices.

A "blind "thrust fault was cored in well 51-8. The thrust fault juxtuposes gently dipping Silurian dolomite over steeply-dipping and overturned Mississippian black limestone and shale. Units on the hanging and footwall of the fault are pervasively fractured and deformed. This hidden structure may have important regional tectonic significance. Steeply-dipping and overturned beds in foot wall point toward a basement-involved fold that is locally thrust faulted. This style of deformation is typical of classic Laramide (Late Cretaceous-early Tertiary) Rocky Mountain basement-cored uplift margins. Several Laramide uplifts are well documented in the southern Rio Grande rift (Seager, 1983).

A deeply-penetrating structure with fracture permeability in basement (Precambrian rocks) may be required to create the geothermal system at McGregor Range. Schmidt and others (1993) present a generalized descriptive classification of the geometric features found in Laramide reverse fault and fold structures. In their study of basement deformation in Laramide structures across the Rocky Mountain region, Schmidt and others (1993) observed that the major deformation of basement rocks occurs in the "forelimb domain." The style of deformation is largely dependent upon the fabric of basement rocks. For instance, foliated rocks, such as schist, show distributed shear or shear on close-spaced faults; while, isotropic rocks, such as granite, maybe pervasively broken at all scales. Shattered-rock domains will provide the best potential reservoir hosts. In any case, the fault enhances the potential for deeply-circulating regional ground water flows through basement rocks and may help explain the McGregor geothermal system.

HYDROGEOLOGY

Paleozoic rock units can act as aquitards or aquifers. Regional geologic information indicates that the El Paso Formation and Montoya Group (Ordovician), and the Fusselman Dolomite (Silurian) may have excellent reservoir potential. As noted by Lucia (1988), these units frequently contain extensively-fractured and brecciated terrane in the Franklin Mountains, Caballo, and southern Hueco Mountains. The breccias formed by collapse of dissolution features and large caverns (Carlsbad Caverns magnitude) which were created during the El Paso-Montoya unconformity and the Fusselman-Canutillo (Lucia, 1988). The most extensive caverns were formed in the El Paso Formation and collapse of the El Paso caverns produced subsequent fracturing, dissolution, and collapse into the overlying Montoya Group and Fusselman Dolomite. It is believed that tabular, laterally-extensive caverns formed in close proximity to paleo water tables. In addition, fracture-controled dissolution formed vertically-oriented caverns and solution cavities. Lucia (1988) presented evidence that most collapse occurred during and after Fusselman deposition.

Preservation or enhancement of permeability and porosity, associated with the breccias and dolomitization, has important implications for geothermal resources in the McGregor Range subsurface because Ordovician and Silurian units are the deepest-seated potential Paleozoic reservoir hosts.

Coring indicated that nearly all Paleozoic units show some fracture permeability; however, the black Mississippian limestone and shale units tend to exhibit less fracture permeability. As predicted by regional geology, important vuggy solution porosity and permeability is prominent in the Ordovician and Silurian dolomitic units.

Major solution permeability is found in wells 45-5 and 46-6 and is especially drammatic in Pennslyvanian limestones near the static water level, above and below intrusive contacts, and near the bedrock-basin fill unconformity. Cavernous intervals were encountered in well 45-5 in Pennslyvanian rocks. Also, stylolites, when present in the Pennslyvanian units, frequently have important solution permeability.

Tertiary felsite sills and laccoliths also show intervals with important fracture permeability in the core holes. Plugs or dikes feeding the sills and laccoliths may provide hydrogeologic windows for outflow of deep-seated geothermal fluids into fractured Paleozoic reservoir hosts.

Tertiary basin-fill units are not hosts for geothermal resources on McGregor Range. On the other hand these units do confine or provide leaky caps over the geothermal systems due their fine-grained (silty and clayey) nature.

Static water level information for the area indicates that the geothermal fluids in the carbonate reservoir have head about 100 feet less than levels observed in non-thermal and thermal (conductively-heated) water in the basin fill deposits. Static level of the carbonate geothermal reservoir ranges between 1,109.5 and 1,118.6 m(3,640 and 3,670 ft) elevation with a gradient to the southeast

THERMAL REGIME

Heat Flow

In general, the background thermal regime of the McGregor Range is typical of the southern Rio Grande rift and ranges from 85 to 123 mW/m^2. Measured heat values reported by Reiter and others (1986); Decker and Smithson (1975); Reiter and others (1978); Reiter and others (1975) are from sites around Orogrande on the west and Cornudas on the east of McGregor Range. Temperature gradient and heat-flow studies by Taylor (1981), Taylor and others (1980) are combined with thirty one temperature gradient measurements by NMSU to produce a detailed heat flow map of the only known geothermal system on McGregor Range (Witcher, 1997) (Figure 4). This heat flow anomaly is more than 50 km^2 and extends southward beyond McGregor Range into west Texas near Hueco Tanks. Anomalies of radon soil gas, soil mercury, surface SP data, and temperature gradients point toward a broadly distributed upflow zone that roughly coincides with the heat-flow closure west of Davis Dome. The northeast and southeast elongation of the anomaly probably represents lateral outflow. Variations in heat flow are due to topography of the Tertiary basin-fill/Pennslyvanian limestone contact where this contact extends below the water table. The silty and clayey basin-fill confines the flow to solution and fracture zones in the limestone below the contact. Total heat loss for the system exceeds 15,000 kJ/s.

Shallow Reservoir Temperatures

Measured reservoir temperatures in the shallow reservoir (less than 1,000 m or 3,000 ft) are shown in Figure 5. The main upflow zone for the system lies in the vicinity of well 46-6. The main outflow extends southeastward from well 46-6 to well 51-8. A relatively intense, but thin eastward outflow extends eastward toward well 45-5 at shallow depth in solution permeability in Pennslyvanian limestone. A planned dipole-dipole resistivity survey by NMSU

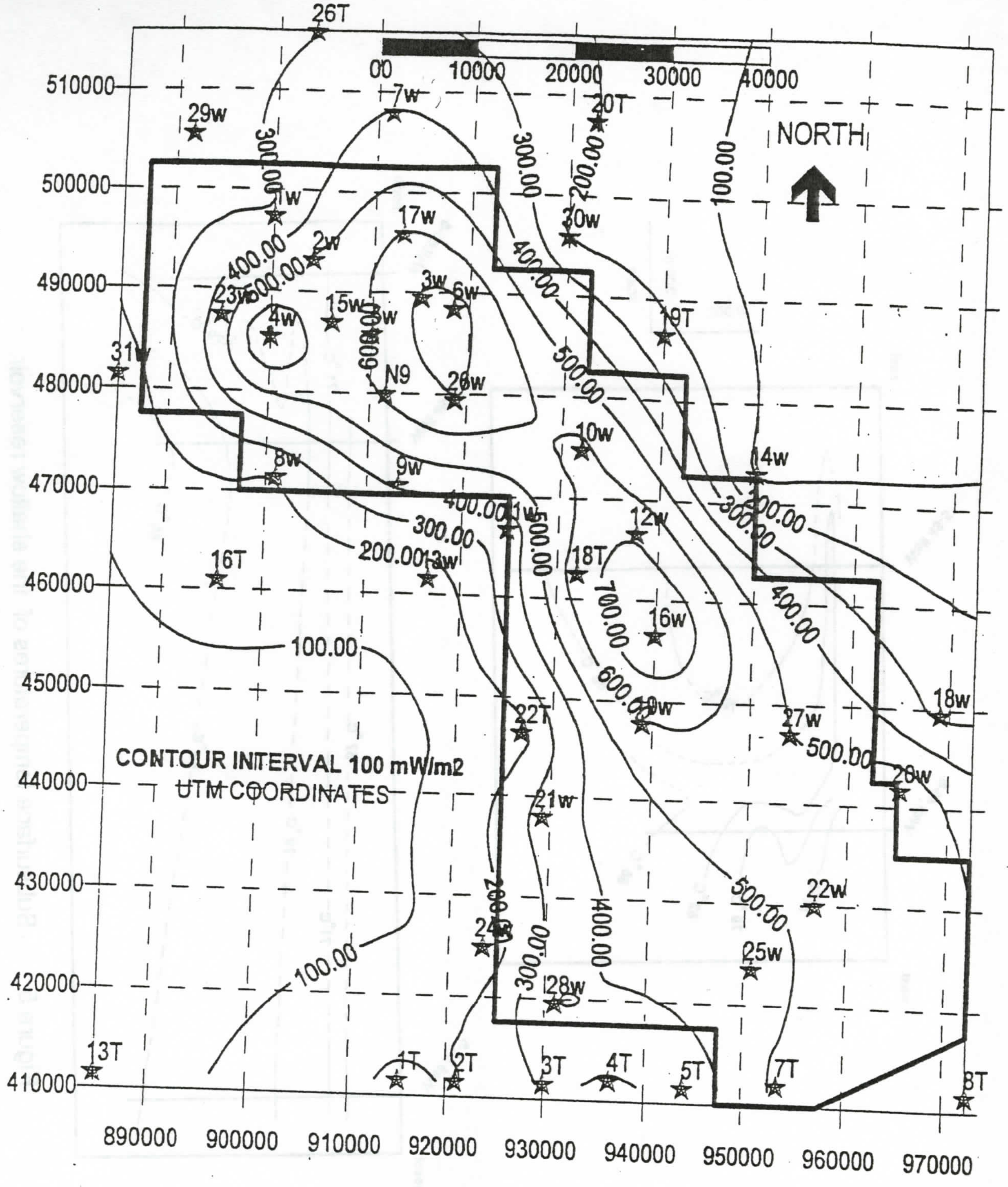

Figure 4 Heat-flow map of the McGregor geothermal system.

mW/m

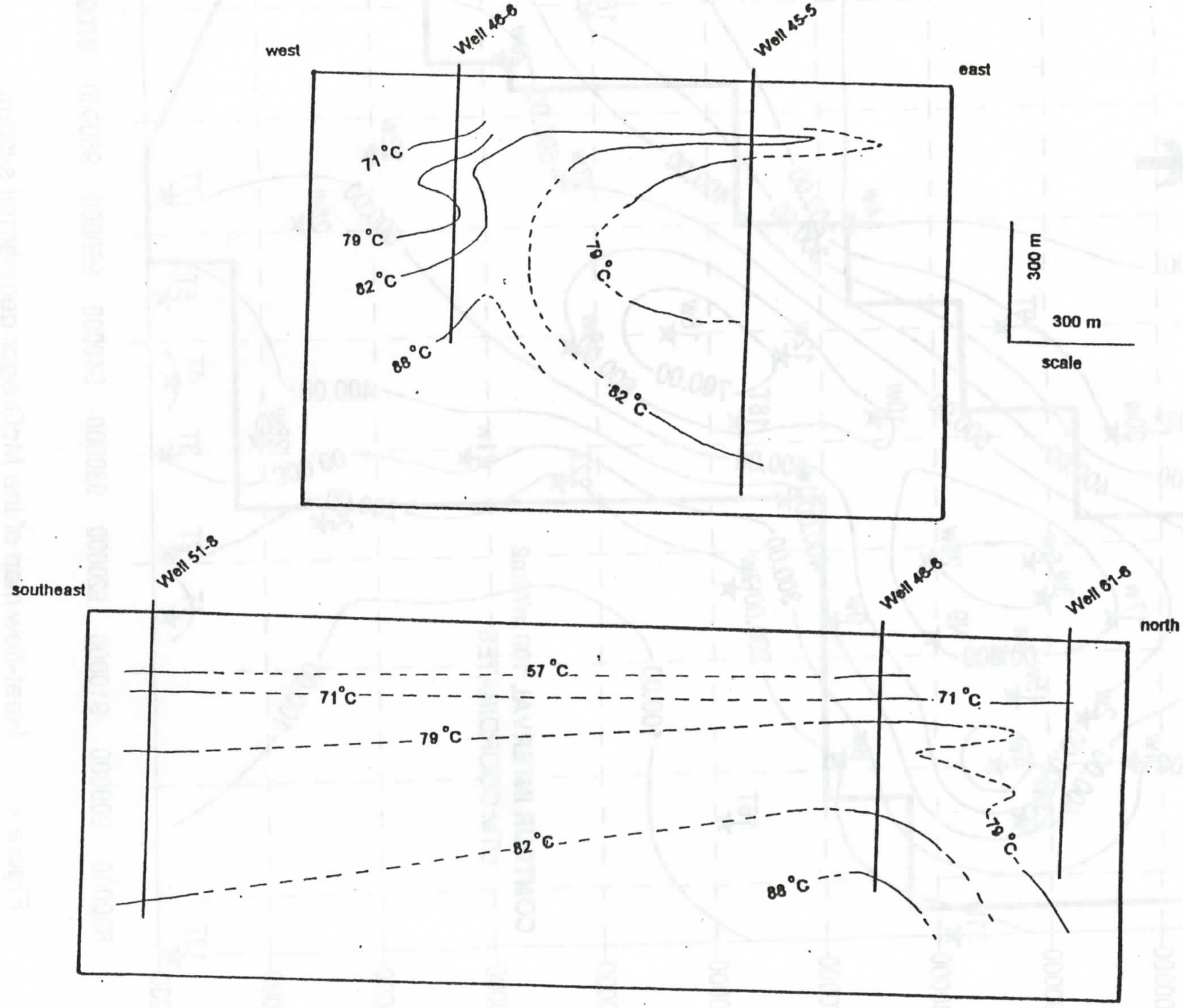

Figure 5 Subsurface temperatures of the shallow reservoir.

and the University of Utah will provide more detail on the upflow and intense shallow upflow zone.

Heat Content

The amount of economically available heat is the geothermal resource base. Less than 10 percent of the heat contained in the reservoir is contained in the fluid and most of the heat is stored in the rock (Muffler and Cataldi, 1978). The economically accessible geothermal resource (geothermal reserves) at McGregor Range will be determined by the end use. No commercial direct-use geothermal operation in New Mexico uses wells deeper than 300 m depth. However, with binary power production or desalination, deep wells may be economic. Determination of the useful resource base employed the volume method of Muffler and Cataldi (1978)

The reservoir volume is based upon the area that circumscribes the 500 mW/m^2 heat-flow contour and a depth interval of 1,000 m:

(10) $Q_r = (1-\phi)(c_r)(\rho_r)(V_r)(Tave - Tmat) + (\phi)(c_w)(\rho_w)(V_r)(Tave - Tmat)$

where:

Q_r	total heat content (geothermal resource base) (J)
ϕ	porosity (0.10 m^3/m^3)
c_w	specific heat of fluid (4,184 J/kg °K)
c_r	specific heat of rock (limestone at 85 °C) (950 J/kg °K) (Robertson, 1988)
ρ_w	density of fluid (1,000 kg/m^3)
ρ_r	density of rock (2,700 kg/m^3)
V_r	volume of reservoir (1,000m x 2,500 m x 6,000 m)
Tave	geothermometer (85 °C)
T_{mat}	mean annual temperature (18 °C)

The total amount of heat in the reservoir ranges from 2.7 x 10^{21}J. The amount of resource that is recoverable for use is much less.

The geothermal reserves are related to the resource base by a recoverability factor:

(11) $Q_u = (Q_r)(R_f)$

where:

Q_u	geothermal reserves (J)
Q_r	total heat content (geothermal resource base) (J)
R_f	recoverability factor (0.15)

The recoverability factor (R_f) is a somewhat subjective number. The recoverability factor is dependent upon the length of time the resource is exploited, reservoir porosity, method geothermal extraction, and natural convective and conductive recharge. Muffler and Cataldi (1978) indicate that recoverability could range up to 25 percent for some hot water reservoirs. A factor of 0.15 is used in this analysis. Recoverable geothermal resources (geothermal reserves) at McGregor Range are estimated to range from 4.1 x 10^{20} J.

GEOCHEMISTRY

Geothermal fluids from the McGregor Range geothermal system are currently poorly characterized. A sampling program of the deep slim-hole core tests is planned for later this year. However, limited data reported in the literature by Henry and Gluck (1981) provides some useful information. Overall the fluids are sodium-chloride composition with total dissolved solids (TDS) ranging from 445 mg/L to 6,590 mg/L. Figure 6 is silica versus chloride plot that may indicate mixing of thermal and nonthermal water is occurring. However, only three data points constrain this possibility. Also, the lower TDS water may simply represent shallow groundwater that has been heated conductively by geothermal waters confined below the sample depth. The chemistry of well M-11 is typical of nonthermal ground water.

Of more importance, the silica geothermometers predict that the maximum reservoir temperature is 109 °C using the quartz (no steam loss-conductive) geothermometer (Fournier, 1977). The quartz geothermometer is best used

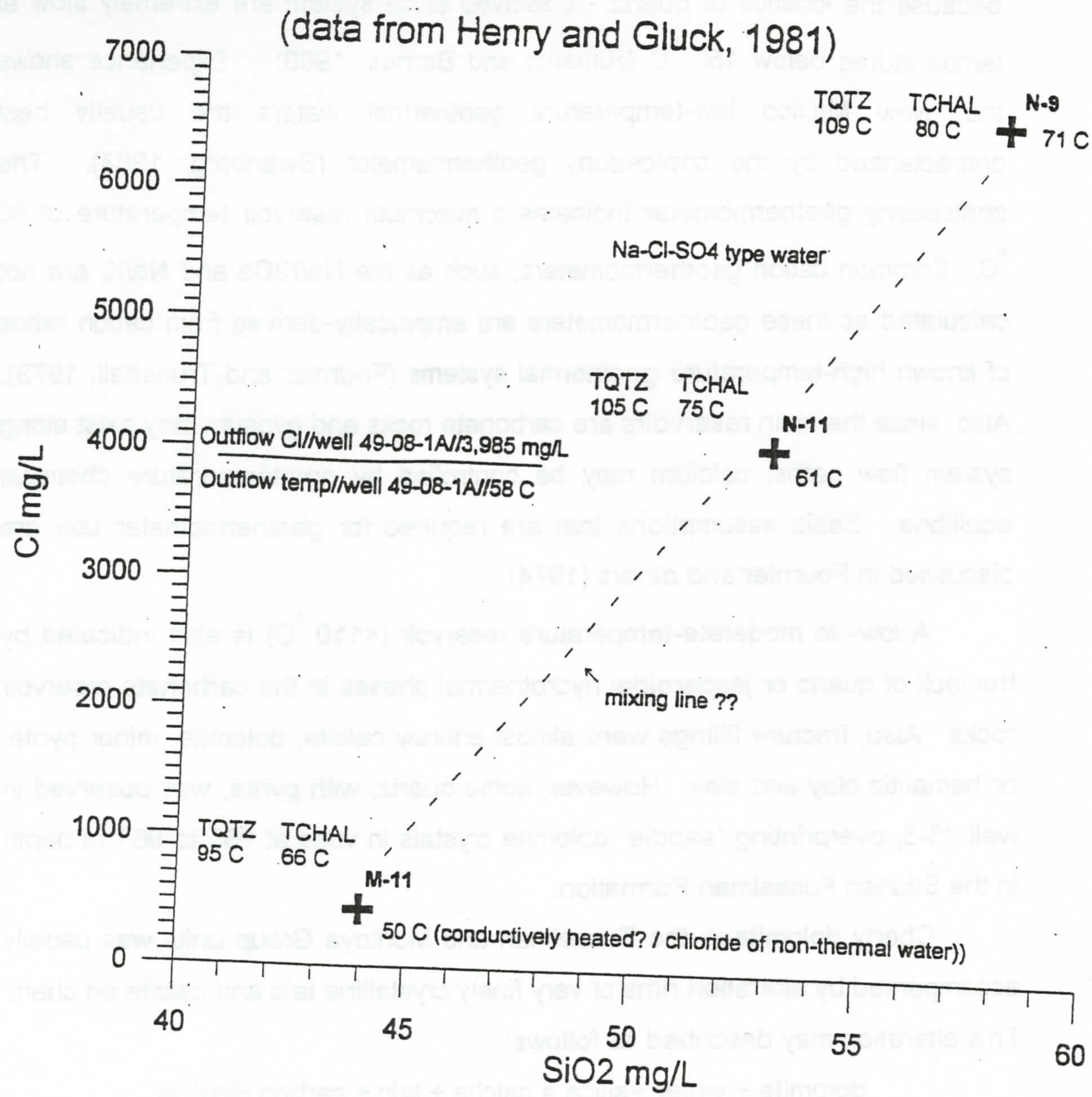

Figure 6 Silica versus chloride concentrations for McGregor hot wells.

where reservoir temperatures are probably much greater than 100 °C. This because the kinetics of quartz - dissolved silica system are extremely slow at temperatures below 150 °C (Rimstidt and Barnes, 1980). Experience shows that New Mexico low-temperature geothermal waters are usually best characterized by the chalcedony geothermometer (Swanberg, 1983). The chalcedony geothermometer indicates a maximum reservoir temperature of 80 °C. Common cation geothermometers, such as the Na/K/Ca and Na/K, are not calculated as these geothermometers are empirically-derived from cation ratios of known high-temperature geothermal systems (Fournier and Truesdell, 1973). Also, since the main reservoirs are carbonate rocks and gypsum may exist along system flow paths, calcium may be controlled by non-temperature chemical equilibria. Basic assumptions that are required for geothermometer use are discussed in Fournier and others (1974).

A low- to moderate-temperature reservoir (<110 °C) is also indicated by the lack of quartz or jasperoidal hydrothermal phases in the carbonate reservoir rocks. Also, fracture fillings were almost entirely calcite, dolomite, minor pyrite, or hematitic clay and clay. However, some quartz, with pyrite, was observed in well 45-5, overprinting "saddle" dolomite crystals in vugs at 960 to 961 m depth in the Silurian Fusselman Formation.

Cherty dolomite in the Fusselman and Montoya Group units was usually accompanied by alteration rims of very finely crystalline talc and calcite on chert. This alteration may described as follows:

dolomite + water +silica = calcite + talc + carbon dioxide

or

$$3CaMg(CO_3)_2 + H_20 + 4SiO_2 = 3CaCO_3 + Mg_3SiO_{10}(OH)_2 + 3CO_2$$

This reaction may also buffer dissolved silica concentrations, making quartz geothermometry invalid. Alteration observed in Tertiary intrusive rocks is believed to be coeval with intrusive activity. Further geochemical study is needed on the fluids and rocks inorder to confidently understand deep subsurface reservoir conditions. Available evidence points to a low- to moderate-temperature (80 to 110 °C) reservoir.

SYNTHESIS

Hydrothermal resources occur in regions where heat flow from the Earth's interior is elevated. The Rio Grande rift provides a thermally-enhanced regional setting (Decker and Smithson, 1975; Reiter and others, 1978; Reiter and others, 1986). Inorder to localize and concentrate heat, several geologic conditions are required. First, water must circulate past the heat source. A suitable heat source maybe concentrated as a "point source" in the shallow crust (magma chamber) or the heat source may be diffuse and deep-seated (high conductive regional heat flow in the crust). Hydrothermal circulation requires a permeable framework or favorable "plumbing" that allows recharge flow, fluid storage, and discharge flow from the system. A variety of structural and stratigraphic elements must work in concert inorder to host a hydrothermal system. Favorable stratigraphy is required to provide deep-seated and laterally-extensive aquifers (reservoirs) and to provide confining aquitards (reservoir caps). Recharge may have a dominant structural or stratigraphic control or both. Generally, structure provides vertical permeability for discharge. Vertical permeability, whether it is for recharge or discharge, is most efficient at *geohydrologic windows*. Witcher (1988) defines *geohydrologic windows* as "outcrop and subcrop terranes underlain by permeable rock where confining aquitards have been erosionally or tectonically stripped away." A geohydrologic window may have structural and stratigraphic attributes. More importantly, a geohydrologic window allows the most rapid upward movement of fluids with the least heat loss. While vertical cross formational flow across aquitards is capable of creating enhanced heat flow and subsurface temperatures (see Harder and others, 1980; and Morgan and others, 1981), the mass and energy flux observed with geothermal systems requires high vertical permeability. Infact, all well studied geothermal systems in the Rio Grande rift are observed to discharge at the surface or into the shallow subsurface at geohydrologic windows (Barroll and Reiter, 1990; and Witcher, 1988). Transfer or accomodation zones are favored sites for geothermal systems in the southern Rio Grande rift (Chapin and others, 1978). These zones generally have enhanced fracture permeability and are relatively high structurely. Both factors favor the creation of geohydrologic windows.

With an average conductive 90 mW/m^2 heat flow, the amount of heat energy leaving a square kilometer is 90 kJ/s. If 10 percent of conductive heat is captured or swept up by ground-water flow, a recharge area of at least 2,000 km^2 is required to balance conductive heat loss over the McGregor geothermal system discharge. The required recharge area has the same order of magnitude as the area of McGregor Range, indicating that the probable recharge for the system is higher elevation terran north, northeast, and east of the extent of the mapped geothermal system. In other words, geothermal potential elsewhere on McGregor Range is unlikely because the region acts as a recharge zone for the system near Davis Dome. An exception may be the narrow region between Highway 54 and the Hueco-Otero Mesa "range front" northward to Orogrande and on to Alamogordo. This region, at relatively low elevation, may contain favorable structurally-high or intrusive hydrogeologic windows such as observed near Davis Dome. However, insufficient data are available to quantify the potential in this narrow strip on the western portions of McGregor Range.

POSSIBLE USES OF RESOURCES

Three potential uses are identified for the known geothermal resources at McGregor Range. These uses fall into two major geothermal technologies, direct-use and electrical power production. Direct-use applications use heat directly without conversion to electricity and are suitable for low-temperature geothermal fluids (<100 °C). Direct-use geothermal technology has potential applicable for spacing heating, heating domestic hot water (showers and mess hall) and for swimming pool heating at McGregor Range Camp. Another direct-use technology that may also have potential is geothermal desalination where the geothermal heat is used in a cascaded, vacuum-distilling process. Currently, potable water is piped uphill to McGregor over as distance of more than 32 km (20 mi).

Generally, geothermal electrical power is only commercially competitive on grid at temperatures above 175 °C for conventional flash steam technology and above 130 °C for binary power technology (DiPippo, R. 1987). However, binary power technology has been applied with geothermal fluids with temperatures between 85 and 130 °C to produce 50 kWe to 1MWe of electrical power (DiPippo, R. 1987, and Bronicki, 1995). Binary power plants use a secondary working fluid which is heated by the geothermal fluid in a heat exchanger. The secondary working fluid consists of organic media, such as isobutane, which vaporizes at lower temperatures than water. The working-fluid vapor turns the turbine and is condensed prior to reheating at the heat exchanger to form a closed-loop working cycle. The geothermal fluids are injected by into the reservoir after heating the working fluid in the heat exchanger.

The economic and engineering feasibility of uses at McGregor Range is not known and is beyond the scope of this report. However, there are several mitigating factors such as the high pumping head (>greater than 140 m or 460 ft) of the geothermal reservoir and the sporadic nature of heat demand at the McGregor Range Camp. For electrical power, very large well production rates (and injection) will be required because the reservoir temperatures are marginal with current binary power technology. However, small-scale power production, coupled with desalination and cascaded direct-use heating, may have an advantage.

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WELL 45-5

Footages (KB)	Unit
0 to 32	Tertiary/Quaternary basin fill
32 to 433	Pennslyvanian cherty limestone
433 to 464	Tertiary felsite porphyry sill
464 to 550	Pennslyvanian cherty limestone
550 to 864	Tertiary felsite porphyry sill
864 to 1195	Pennslyvanian cherty limestone
1195 to 1857	Devonian/Mississippian limestone and shale
1857 to 3099	Tertiary felsite porphyry sill
3099 to 3129	Devonian/Mississippian limestone and shale
3129 to 3649	Silurian Dolomite
3649 to 3961	Ordovician Dolomite

WELL 46-6

Footages (KB)	Unit
0 to 684	Tertiary/Quaternary basin fill
684 to 1145	Pennslyvanian cherty limestone
1145 to 1284	Tertiary felsite porphyry sill
1284 to 1741	Pennslyvanian cherty limestone
1741 to 2258	Devonian/Mississippian limestone and shale

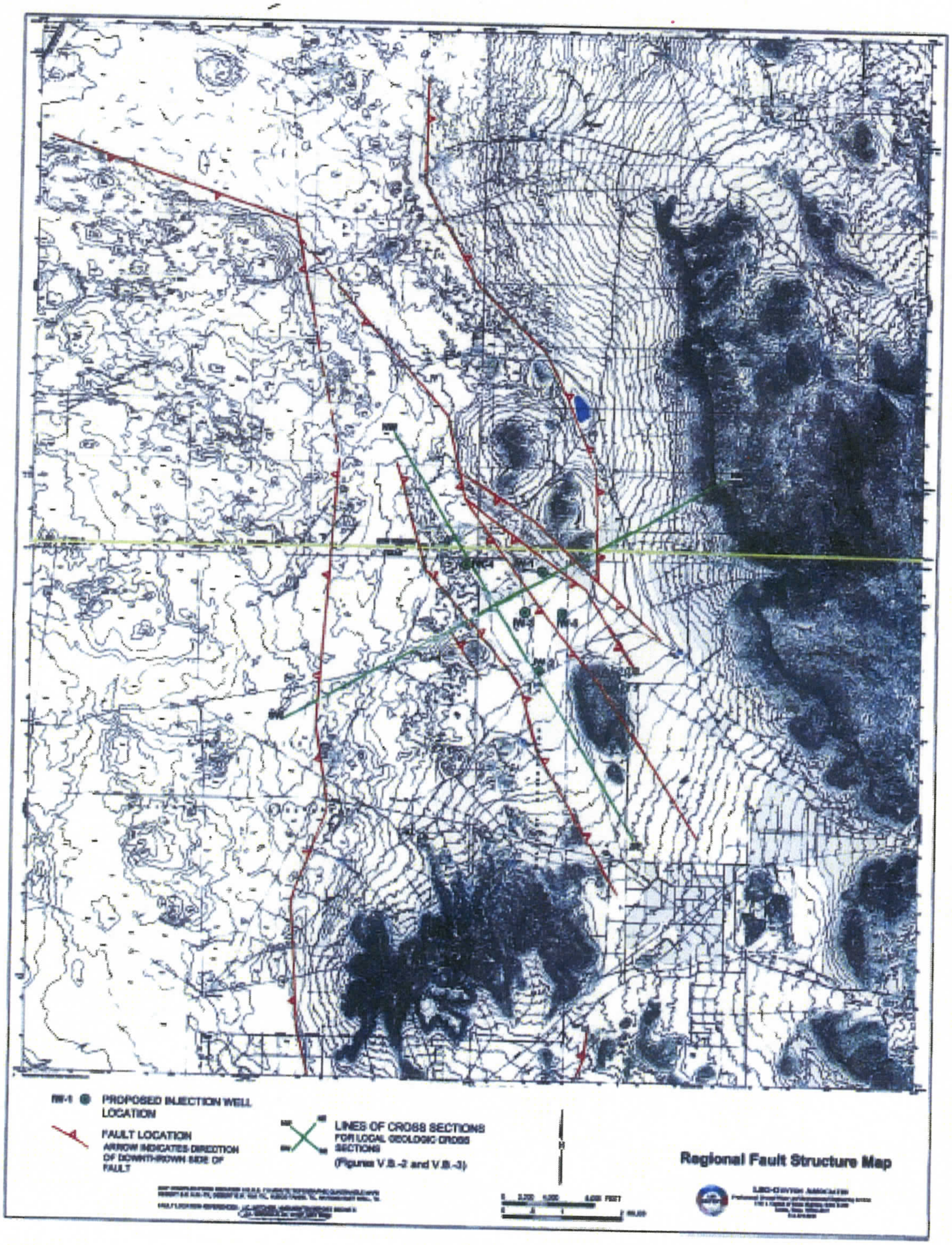
WELL 51-8

Footages (KB)	Unit
0 to 460	Tertiary/Quaternary basin fill
460 to 655	Tertiary felsite porphyry sill
655 to 770	Pennslyvanian cherty limestone
770 to 1503	Devonian/Mississippian limestone and shale
1503 to 2239	Silurian Dolomite
2239 to 2240	thrust fault (gouge)
2240 to 2479	Mississippian limestone and shale (steeply overturned)
2479 to 2573	Pennslyvanian cherty limestone (steeply overturned)

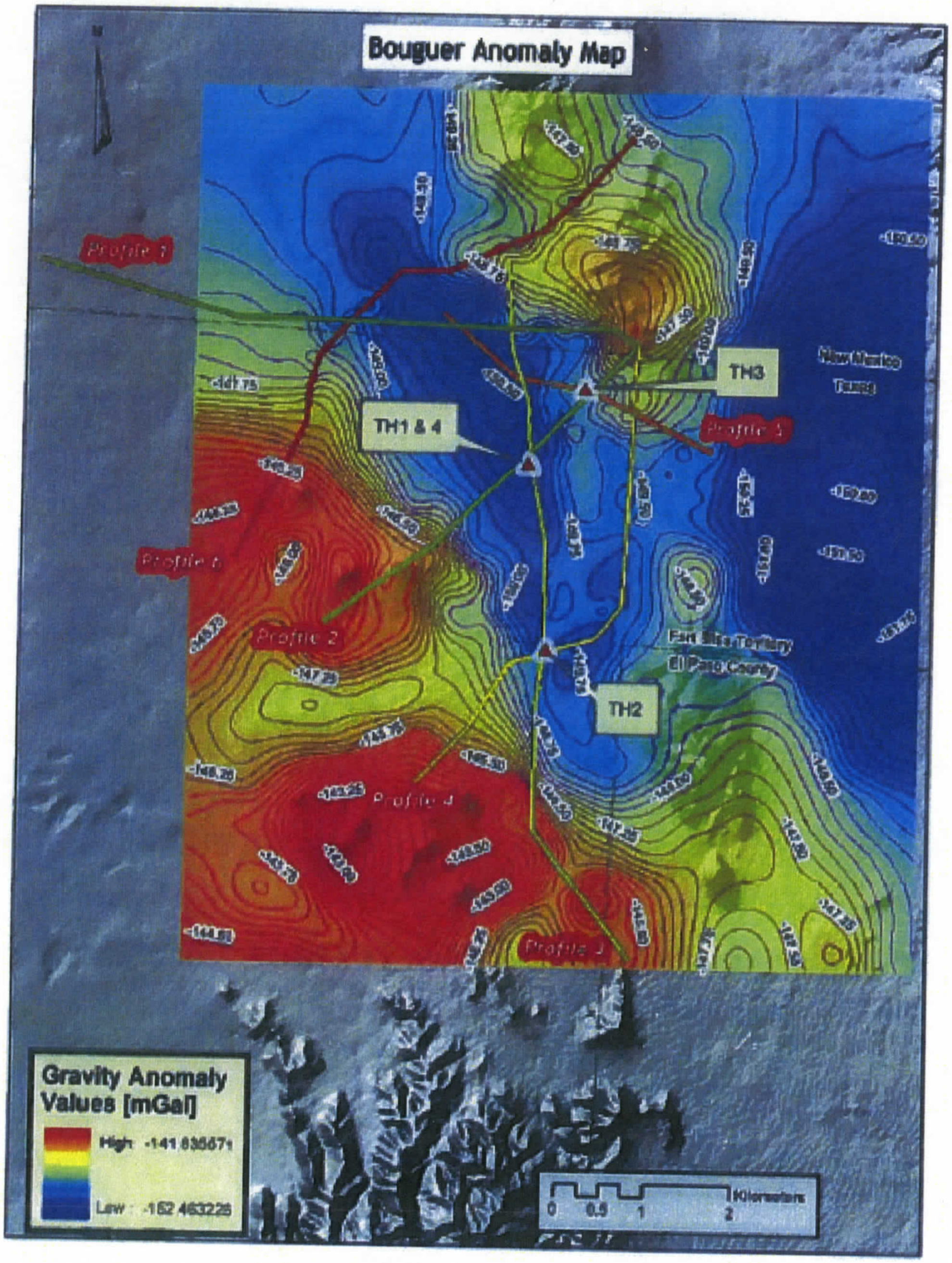
WELL 61-6

Footages (KB)	Unit
0 to 605	Tertiary/Quaternary basin fill
605 to 1430	Tertiary felsite porphyry sill
1430 to 1760	Pennslyvanian cherty limestone
1760 to 2018	Devonian/Mississippian limestone and shale

Fault Structure Map
Injection Well Site Area



Bouger Anomaly Map
Injection Site Area



Bouguer Anomaly Map, Spline Tension Interpolation, Wt. 10,
No. of Points 12, Grid cell size at 1 second (101.45 ft.)

Source: J. Granillo, 2004

McGregor Range Heat Flow Map (Whitcher, 1997)